BRITISH COLUMBIA DEPARTMENT OF MINES

HON. E. C. CARSON, *Minister* JOHN F. WALKER, *Deputy Minister*

BULLETIN No. 18

SPECIMENS AND SAMPLES

THEIR TREATMENT AND USE

by

OFFICERS OF THE DEPARTMENT OF MINES
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PREFACE.

THIS bulletin, written for the prospector, deals with the specimens and samples he takes in the field and the treatment they receive in the Department of Mines laboratory in Victoria. Specimens and samples are taken for different purposes and accordingly are different in character. Part I. of this bulletin brings out the differences between specimens and samples; the usefulness of each; how they should be taken, labelled, and shipped; and how specimens and some samples can be studied in the field. Amongst other things Part I. stresses the need for proper care in taking specimens and samples, in making records concerning them, in packaging and shipping them, and in sending instructions to the laboratory. These items are important whether material is sent to the laboratory of the Department of Mines or to any other laboratory. Part II. describes how specimens and samples are examined and assayed in the Department's laboratory in Victoria; and Part III. contains information on the functions of the Department of Mines sampling plant at Prince Rupert, and how shipments of ore may be made to it.

In the Department of Mines laboratory, rock and mineral specimens found in British Columbia are identified, and samples submitted by *bona-fide* prospectors are assayed free of charge (*see* page 15). Custom assaying and custom analytical work, which are done by a number of firms of assayers and analysts in the Province, are not done by the Department.

The Department will be glad to supply further information about the services which it offers to prospectors; and to receive suggestions from prospectors concerning the services given, including the form of specimen and sample tags which are now offered free of charge to *bona-fide* prospectors.

PART I.

TAKING SPECIMENS AND SAMPLES AND THEIR TREATMENT IN THE FIELD.*

SPECIMENS.

A good specimen consists of one or more pieces typical of an ore, a mineral, or a rock, large enough to show the character of the material. Specimens are especially useful for close study, either in the field or in the laboratory, thus permitting exact identification of rocks or minerals. They are also useful as records, to assist the memory, and permit comparison with specimens from different points or with rock in place.

A specimen may be studied in the field with the aid of a hand-lens, pocket-knife, and other simple equipment, thus obtaining immediately information of great value in prospecting; or the specimen may be studied more elaborately in a laboratory, where microscopic examination may be made of a polished surface—if it contains sulphides, or of a thin section or powder for determination of translucent minerals, or chemical tests may be used to determine minerals. It should be noted that these are distinctly different procedures from quantitative analysis (assaying) applied to samples.

Care, patience, and at times hard work, are required in selecting and breaking proper material for specimens, and in trimming rock specimens to suitable size. Identifying weathered material is apt to be difficult and unsatisfactory, and as weathering rarely goes deep in British Columbia we are usually interested in fresh, unweathered rocks and minerals. For these reasons a specimen should consist of unweathered material, and several sides of an ore or rock specimen should be freshly broken. As a specimen of an ore or rock, a piece 1 by 2 by 3 inches is usually large enough. A few grains or even a single crystal may be enough to permit identification of a mineral; however, it is better to have too much than too little.

Concentrates, or grains selected from concentrates, obtained in panning unconsolidated material or vein-matter which has been properly prepared, may be used as specimens. Further reference to concentrates will be found later under the headings "Study of Specimens and Samples in the Field," page 14, and "Sampling Unconsolidated Deposits," page 10.

If the prospector is interested in a particular mineral in a specimen it is a good idea for him to use a crayon to mark a ring around the part of the specimen in which that mineral is found. If interested in the identification of grains of some particular material or mineral in gravel or in a placer concentrate it is best to separate that material or mineral. Marking or separating the material of interest will be of use when studying the material later; and, if the material is sent to a laboratory for study, there will then be no room for doubt concerning the particular mineral or grains of material in which the submitter is interested.

Each specimen should be identified by marking it with an appropriate symbol, lettered with india ink or with crayon on an unimportant part of the specimen, or the symbol may be lettered on a piece of adhesive tape which is stuck to the specimen. Another method is to wrap with the specimen a piece of paper or thin cardboard on which the symbol is written or printed. A suitable record should be made at the time each specimen is collected; suggestions for the record are given on pages 15 to 18.

Bruises, scratches, or other damage reduce the usefulness of specimens. Therefore each specimen should be protected by being wrapped carefully in several thicknesses of paper—say, half a sheet of newspaper to an average specimen. It is particularly necessary to have specimens individually wrapped if several of them are to be carried in a pack-sack or shipped in one package.

* By H. Sargent, Chief Mining Engineer.

SAMPLES.

A sample consists of a relatively small quantity of material (usually a few pounds) taken to represent part of a mineral deposit or a quantity of broken material. Samples may be taken from lode deposits (veins or other mineralized bodies of rock) or from unconsolidated material (placer). To be of use a sample must be taken in such a way that the assay* of the sample will correspond closely with the grade of the section sampled. A well-taken sample from a lode deposit consists of many small pieces of rock taken in a systematic, uniform, and impartial manner.

The assaying (quantitative analysis) of a sample, done in the chemical laboratory or assay office, is an elaborate process which calls for the use of valuable materials and of the assayer's time. Therefore assays are warranted only on samples which were well taken.

At this point it is in order to say that the compositions of most minerals are well known, and that one has only to turn to one of many books on mineralogy to learn that pure galena, for example, contains 86.6 per cent. lead, or pure chalcopyrite 34.5 per cent. copper. Therefore there can be little point in sending in one or two lumps consisting essentially of one mineral to be assayed for its principal metallic constituent. However, there may be very good reason for having assays made to determine the more valuable metals which may be present in small but important quantity intimately associated with, or in some cases actual minor constituents of, pure minerals. Thus we might well need to have determined the gold and silver content of samples consisting essentially of galena or chalcopyrite or the cadmium or indium content of a sample consisting essentially of sphalerite.

In the following general discussion reference will be made to lode deposits, but the principles also apply in sampling placer deposits. Procedure followed in taking samples is outlined at a later point under the heading "Sampling Lode Deposits." The intervening paragraphs outline uses of samples and principles of sampling.

PRECISE SAMPLES properly spaced permit outlining closely whatever parts of a mineralized body are of commercial grade, and make it possible to calculate precisely the average grade of each part sampled. If the workings, other exposures, or drill intersections demonstrate the continuity of profitable mineralization vertically as well as horizontally it is possible to calculate the volume and average grade of the ore-body.

Precise samples are usually taken by or under the supervision of an engineer. Each sample is taken with elaborate care and each measurement is made closely and recorded accurately. If a property is being considered for purchase, any ore-body which has been indicated will be sampled in this manner. The sampling will cover the full width of the ore-body and sample sections will be spaced at intervals of a few feet along the strike.

INDICATOR SAMPLES are taken as a preliminary step in examining a mineral deposit, or to assist prospecting for and exploration of mineral deposits by giving indications of the distribution of values and the kind of mineralization with which values are associated. Indicator samples are taken in the same manner as are precise samples, but as they are not to form the basis for close estimates of the grade of an ore-body some of the refinements used in taking precise samples can be omitted. In general, prospectors take indicator rather than precise samples.

The person taking indicator samples should keep clearly in mind the fact that he requires reliable information which is only obtained if reasonable care is used. A sample consisting of one or two pieces knocked from an outcrop or picked from a pile of broken material cannot be depended upon to represent the mineralized body or pile of broken ore fairly.

PRINCIPLES OF SAMPLING.—Mineral deposits are usually much smaller in one dimension than in the others, and this smaller dimension—width or thickness—is usu-

* Assays are expressed as "troy ounces per ton" for precious metals (gold, silver, platinum, etc.), and as percentages for base metals or minerals.

ally at right angles to any banding or layering of the deposit. As values are apt to be different in adjoining bands or layers, a sample taken at right angles to them will give most information about the average grade of the deposit. For this reason samples should be cut across the mineral deposit and not along it. The most favourable section for sampling is at right angles to the walls of the deposit, but in steeply dipping veins samples are frequently cut in horizontal sections which are not quite at right angles to the walls unless the vein stands vertically. The important dimension for any sample is the width which it represents. A sample width of 5 feet means that the sample was cut across a width of 5 feet, which may be the full width of the mineral deposit or may be part of the width. In the latter case such other samples as are necessary are cut so that the full width of the deposit is represented.

A sample must be typical of the material it is to represent, and also must represent quantitatively all the constituents of the material sampled. That is, a sample should contain all the minerals in the same proportion as they exist in the material sampled, and should contain the same volume of material from each inch of width sampled. Thus in sampling a banded vein, if one band is twice as wide as another, the sample must contain twice as much material from the wider band as it does from the narrower one.

Usually metallic minerals, and especially the precious metals, are irregularly distributed through the gangue (quartz or other rock-forming minerals). The gangue is usually harder, more difficult to break, and less apt to break to fine grains than are the metallic minerals; and brittle material is apt to fly off and be lost when it is broken. To be truly representative the sample must contain the proper proportion of all parts of the material sampled, regardless of the ease or difficulty in breaking. It is worth noting that a sample containing an excessive proportion of either coarse or fine material usually will not truly represent the section sampled.

A sample must be large enough to represent fairly the various kinds of material in the rock sampled. In general, the more uniform the material sampled the smaller the sample may be. Provided samples are taken fairly, the larger the sample the better will be its chance of being truly representative. But merely taking a large sample is not enough. *Good sampling requires taking an equal quantity of rock from each unit of width in a section, usually at right angles to the walls of the mineralized body.* From 1 to 2 lb. of material is usually taken per foot of width of the section of rock sampled. If the values are distributed very irregularly, a quantity greater than 2 lb. per foot of width may be required. Because mineralization is rarely uniformly distributed, several and often many samples will be needed if the grade of a mineral deposit, even of moderate size, is to be estimated accurately.

If the differences in hardness of the various bands or parts of a mineralized body are not great, a fair sample can usually be cut provided a conscientious effort is made to include a uniform quantity from each inch of width across the mineralized body, regardless of the hardness or of the amount of mineralization. If there are marked differences of hardness or of mineralization, more dependable results will be obtained if the total width to be sampled is divided into parts, each of which consists of material of about the same hardness and degree of mineralization, and a separate sample is taken from each part. Let us suppose that a vein 4 feet wide includes 6 inches at the hanging-wall heavily mineralized with sulphides, that the adjoining 2 feet 3 inches consists of quartz with scattered grains of sulphides and that the remaining 1 foot 3 inches to the foot-wall consists of vein-matter which has been crushed to small fragments. In this case three samples should be taken to represent the full width of the vein (Fig. 1).

Because failure to take an entirely uniform quantity of material for each unit of width sampled is less serious if the sample width is not too great, and because the distribution of values is indicated more clearly by samples of moderate rather than large width, the maximum width from which a single sample is taken is usually not

more than 3 to 5 feet. If the lode is more than 5 feet wide (3 feet in the case of high-grade deposits), even though the mineralization seems evenly distributed, two or more samples should be taken, each representing part of the width and together representing the full width of the lode. Fig. 2 shows a wide vein from which two samples are taken to represent the full width.

If the exposed surface of a vein is irregular—that is, if parts of the surface are of markedly different slope—it is best to divide the width into parts, each one of which is essentially of uniform slope, and from each such part to take whatever number of samples the differences of hardness or of mineralization require (Fig. 3).

SAMPLING LODE DEPOSITS.—Samples can be cut with a prospector's pick or with moils and a hammer. All the pieces of rock broken off for the sample should be caught in a sample sack or box, or on a sampling sheet of canvas or oilcloth. To prevent salting with material from some previous sample, the sacks, box, or sheet used should be shaken or brushed free of all adhering material before beginning to cut a sample. Sacks are cleaned best by shaking thoroughly and then turning them inside out. If caught in a box or on a sampling sheet, the sample should be transferred at once to a clean sample sack. As soon as a sample has been cut the essential details should be recorded, the identifying tag or slip of paper should be made out, folded so as to protect the writing, and enclosed with the sample in the sack, which should be tied securely at once.

Two types of samples are commonly taken:—

(*a*.) Chip sample, consisting of chips taken from points uniformly distributed in a band or grid extending across the width sampled.

(*b*.) Channel sample, containing all the material from a channel of uniform width and depth, cut straight across the width sampled.

Each type has advantages; experience has shown that for some types of mineralization chip samples are superior, while for other types channel samples are better.

In taking a chip sample it is a good plan to draw two parallel lines about 6 inches apart at right angles to the strike of the vein and extending from one wall to the other; and to divide the space between these lines into 3-inch squares. In some types of mineralization a grid with wider spaces is used. The lines can be drawn with a crayon or scratched with the point of a pick. A chip of approximately the same size is then broken from about the centre of each square. The chips should be caught in a bag or box or on a canvas as they are broken from the rock. If too much breaks off at any point, the material should be broken into smaller pieces and the excess discarded. Chip samples can usually be cut with a prospector's pick.

In taking a channel sample two parallel lines, 2 to 4 inches apart, are drawn straight across the vein. All the material between the lines to a uniform depth, say half an inch, is then cut out for the sample and all the pieces are caught carefully. If material breaks from outside the lines, or too deep, the excess should be discarded. In some cases it may be possible to cut a fair channel with a pick, but using moils and a hammer gives better control and permits cutting a uniform channel where that cannot be done with a pick.

SUMMARY OF PROCEDURE IN SAMPLING LODE DEPOSITS.

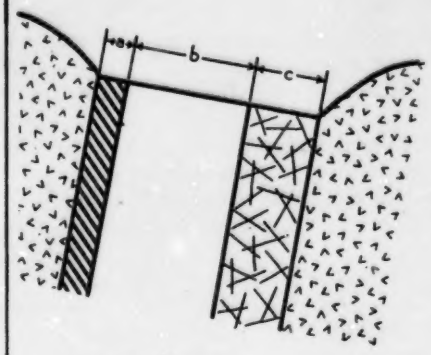
(1.) The sampling sheet, box, or sack to be used is cleaned carefully.

(2.) The surface to be sampled is cleaned of loose material and projecting pieces of rock are trimmed off.

(3.) Two properly spaced parallel straight lines to guide the sampler are drawn from one wall to the other on the surface to be sampled.

(4.) The number of samples to be taken along the section is decided upon and the part to be included in each is marked.

(5.) The sample is cut, the fragments being caught on a sample sheet, in a box, or directly in a sample sack.



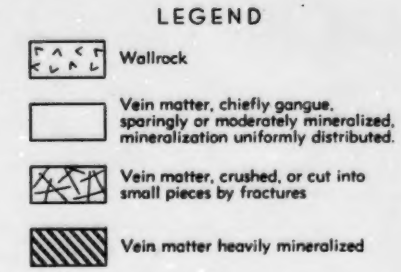

LEGEND
Wallrock
Vein matter, chiefly gangue, sparingly or moderately mineralized, mineralization uniformly distributed.
Vein matter, crushed, or cut into small pieces by fractures
Vein matter heavily mineralized

Figure 1

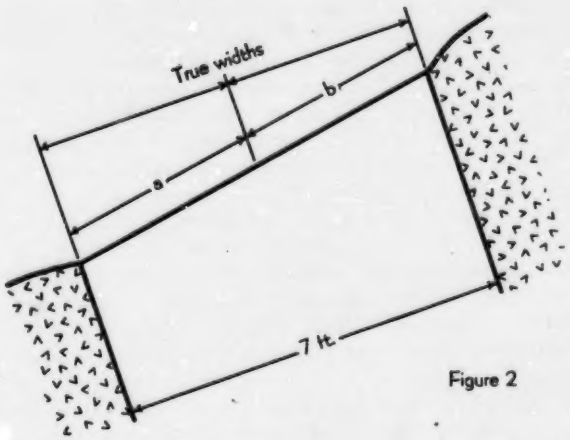


Figure 2

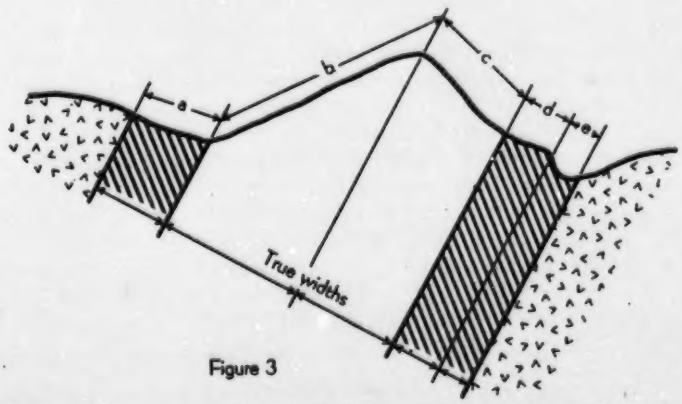


Figure 3

The surfaces along which samples are cut are indicated by letters (a, b, c, d, e). Where these do not represent true widths, the equivalent true widths are indicated.

(6.) A record is made of the details of the sample, and the assays required are noted on a sample tag which is put in the sample sack.

(7.) The sack is securely tied ready for shipment to the laboratory for assay.

SAMPLING UNCONSOLIDATED (PLACER) DEPOSITS.—Sampling unconsolidated deposits and concentrating the heavier materials of the sample, by panning or other means, is useful in the search for economic placer deposits and for indications of lode deposits.

Deposits of gravel, sand, or other unconsolidated material may contain gold or other valuable minerals. Mining such material has been almost exclusively for gold in British Columbia, but prospectors should bear in mind that platinum, tin, tungsten, and certain gem stones are recovered from deposits of unconsolidated material in various parts of the world.

Precise sampling of placer deposits generally calls for the systematic sinking of test-pits, shafts, or bore-holes through the unconsolidated material and for a short distance into the underlying bed-rock, or drifting on bed-rock. Prospectors are usually concerned with discovery and preliminary sampling; accordingly they take samples of gravel, sand, or soil from creek-beds, the sides of streams, and from hillsides. It may be necessary to do a moderate amount of digging at any such point, and it may be necessary to sink test-pits from time to time.

If all the consolidated material, from the grass roots to bed-rock, must be handled it will be useful to know whether or not the upper part contains recoverable values. In general, the values are found concentrated in cracks and depressions in the upper part of the bed-rock and in a few inches of gravel lying immediately on bed-rock. The overlying gravel usually is poor or barren, although such is not always the case. If values are found to be concentrated in a "pay-streak" on bed-rock or on false bed-rock, the prospector can dispense with the labour of testing the much larger quantity of overlying gravel. Where possible the testing should extend down to bed-rock. Care should be taken that for the area of the particular sample all the material on bed-rock or contained in crevices is gathered up and included in the sample.

The valuable minerals in placer deposits are heavy. Concentrating a sample by using a gold-pan, rocker, or sluice retains the heavy minerals and gets rid of the lighter material. In testing gold placers the gold contained in each pan is weighed or estimated. If the gold in each pan is too little to weigh on scales which are available the weight should be estimated and the gold from a number of pans should be combined for weighing to check the estimates.

Fire assays of gold in placer samples include gold locked up in sulphides or quartz and also flour-gold as well as the gold recoverable by placer-mining methods. For this reason fire assays on placer material cannot be interpreted in terms of gold recoverable by placer-mining; therefore separating the gold from the other material in the concentrates and weighing or estimating the weight closely is preferable to sending the concentrates to the laboratory for fire assay. The same can be said, to a degree, for tin or tungsten placers; but, as the tin and tungsten minerals are harder to detect than is gold, it is desirable, particularly in the prospecting stage, that from time to time samples be sent in for laboratory determination or assay.

Careful reconcentration of concentrates in a smaller gold-pan, removal of magnetic black sands with a magnet, and blowing lighter material from the dried concentrates, help in separating the gold from the other material. Amalgamation with mercury (quicksilver) also assists in separating gold from other material. The gold from several pans can be amalgamated in the same two or three drops of mercury, thus giving a bead large enough to weigh. The amalgam must be heated in a retort* or in an open container to drive off the mercury and leave the gold behind.† The mercury

* A small quantity of amalgam can be put in a hollow in half of a potato. The other half is then wired to the first and the potato is roasted in the fire.

† To avoid mercurial poisoning, such work should be done in a well ventilated place, preferably out-of-doors; care must be taken not to transfer mercury from the hands to the mouth, nor to breathe the fumes.

recovered from retorted amalgam almost always contains some gold, and therefore should not be used in testing samples. Only clean gold can be amalgamated. Gold coated with tarnish or rust will not combine with mercury unless the coating is removed. Gold can be amalgamated in an ordinary pan if a little mercury is poured in and the contents of the pan are stirred vigorously. If concentrates are being amalgamated in a small pan two or three drops of mercury should be enough. The mercury will become changed to pasty amalgam if it takes up enough gold. The amalgam can be readily separated from the remainder of the concentrates by panning.

If a balance suitable for weighing the gold is not available the weight of gold must be estimated. It is important that the weight and value per pan be determined accurately, as an error of 1 cent per pan would be equivalent to about $1.75 per cubic yard of gravel. A single pan does not provide a safe basis for estimating the gold content of any yardage of gravel.

Almost invariably some silver, copper, iron, or other metal is alloyed with gold found in placer or lode deposits. The purity or fineness of gold is expressed parts per thousand; thus gold "1,000 fine" is 100 per cent. pure gold, gold "800 fine" contains 800 parts of gold and 200 parts of other metal per 1,000 parts. At the present time for a troy ounce of gold 1,000 fine the mint pays $38.50, less a small handling charge. For an ounce of gold 800 fine the mint settlement would be $30.80, less the handling charge.

The metals alloyed with it influence the colour of gold. Usually all gold from one creek has about the same colour and fineness. The fineness, in addition to determining the value per ounce, has an important bearing on the weight of a piece of gold of any particular size.

If the weight of grains or nuggets of gold is to be estimated, it will help greatly if the estimator can compare the grains of which he wishes to estimate the weight with grains which have been weighed accurately. This can be done conveniently if weighed grains from small to large are glued to a card on which the weight of each grain is written. The grains can be weighed on a sensitive balance. The card should be protected from wear and can be carried conveniently in a note-book. It is worth remembering that a porous nugget, or a spongy bead obtained by driving the mercury from amalgam, will weigh much less than a compact nugget of the same size, and that a single small compact grain of gold will weigh as much as a large number of flaky colours.

The table on page 12 lists the weights of grains of gold, either egg-shaped (oval with circular cross-section) or spherical. The weights are calculated for gold 825 fine in which the only other element present is silver. The egg-shaped grains are of the size that is commonly called "wheaty" gold. Most grains or nuggets of placer gold are rounded, but they tend to be irregular in shape, and most of them are flattened so that few nuggets would correspond closely with true oval or spherical shape. For nuggets oval or circular in one section but flattened rather than circular in the cross-section the weight can be considered as proportional to the thickness; thus a grain one-eighth of an inch in diameter and one sixteenth of an inch thick would have half the weight of a one-eighth inch sphere. Use of the table will not make possible accurate estimation of nuggets of all sizes, shapes, and fineness, but may help in estimating the weight of nuggets of rounded shape within the range of sizes listed.

The smallest grain listed in the table has a diameter of one sixty-fourth of an inch. Such a sphere of gold of the fineness listed would be worth about one-twentieth of a cent. It could readily be hammered out into a thin flake, one-thousandth of an inch thick, which could be cut up into many smaller flakes comparable with the fine colours found in some placer deposits. Gold-leaf can be beaten out to about one three-hundred-thousandth of an inch thickness. A piece 1 inch square then would have a value of about one-tenth of a cent. "Colours," the thin tiny flakes of gold too small to be classed even as tiny grains, may weigh so little that a thousand or more are required to contain gold worth 1 cent. Fine colours unless extremely abundant will not yield

enough gold to be of interest to the individual placer-miner. If the gold on a creek were entirely in fine colours, averaging 500 to a cent, a man panning fifty pans per day would have to recover 5,000 colours per pan in order to make $5 per day. It is obviously impossible to count such numbers of colours; however, an experienced man is able to form a fair idea of the combined value of the fine colours by noting the length of the "tail" or string of colours when gravel is panned down so that only the heaviest material remains.

Let us suppose that in testing placer ground, a pit was sunk 2½ feet to bed-rock. The upper gravel yielded some fine colours. All the gravel from the pay-streak, on 1 square foot of bed-rock, amounting to 6 pans yielded:—

Correction, Bulletin 18. Please paste on page 12, covering upper table.

	Estimated Value.		Remarks.
		Cents.	
1 nugget 5/16" × 3/32" × 1/32"	½ of 36¾c.	=12¼	The thickness is ⅓" of 3/32"
1 nugget ⅛" diam. × 1/16" thick	½ of 26c.	=13	1/16" is ½ of ⅛"
2 nuggets 3/32" diam. × 1/32" thick	2 × ⅛ of 11c.	= 7⅓	
6 nuggets 1/32" diam.	6 @ 2½ to 1c.	= 2½ —	
75 colours estimated 25 to 1c.		3	
Total, say,		38	
Average per pan		6⅓	

This result, 38 cents per square foot of bed-rock, is equivalent to an average of about $4.10 per cubic yard of gravel for the depth of 2½ feet from the surface to bed-rock. If other test-holes gave similar results one would conclude that the ground is not rich enough to pay wages to a man panning, especially as he would have to get rid of the much poorer gravel lying above the pay-streak; however, it might be worked with a rocker, and with an adequate supply of water and enough gravel to warrant the expense of building flumes and sluices such ground might be sluiced profitably.

Weights and Values of Grains of Gold.

Shape—Oval with circular cross-section.

Length. (In.)	Diameter. (In.)	Weight. (Oz.)	Value.
⅛	1/16	0.0023	$0.06½
¼	1/16	0.0045	.13
¼	3/32	0.0102	.29½
5/16	3/32	0.0127	.36¾
5/16	⅛	0.0226	.65½
⅜	⅛	0.0272	.78½
⅜	5/32	0.0425	1.22¾

Shape—Spherical.

Diameter. (In.)	Weight. (Oz.)	Value.
1/64	0.00002	20 to 1 cent
1/32	0.00014	2½ to 1 cent
1/16	0.0011	$0.03¼
3/32	0.0038	.11
⅛	0.0090	.26
5/32	0.0177	.51
3/16	0.0305	.88

Weights calculated for gold-silver alloy 825 parts gold, 175 parts silver. Value calculated at $38.50 per troy ounce of fine gold.

STUDY OF SPECIMENS AND SAMPLES IN THE FIELD.

In prospecting for, or exploring, mineral deposits the identification of rocks and minerals is of great use. If the information can be obtained on the spot it is much more helpful than if one has to wait while specimens are sent to the laboratory and the results of the laboratory study are sent back by mail. In addition to identifying rocks and minerals it is often possible, by careful examination of a deposit and by testing samples in the field, to form a reasonably close estimate of the grade of a deposit. The following paragraphs deal with studying samples and specimens in the field in order to gain information which will guide prospecting.

Minerals can usually be distinguished from each other by differences in their characteristics, such as colour, streak, transparency, hardness, specific gravity, fracture, cleavage, magnetism, and crystal habit. The use of a pocket magnifying-glass, a streak plate (an unglazed porcelain insulator, cost 2 or 3 cents, will serve), a steel knife, a magnet, and good judgment, will make it possible to determine most of these characteristics in the field.

Handbooks on mineralogy or prospecting, and tables for determining minerals, list the characteristics of minerals. Such a book* or table should be carried in the field. With this information and simple equipment a good prospector can identify most of the minerals he comes upon, and needs only to send in for laboratory determination occasional specimens about which he is uncertain.

The ore minerals of copper, lead, and zinc can usually be identified with little difficulty. To contain enough metal to be an ore, mineralized rock must contain at least 2 or 3 per cent. of copper mineral or about 10 per cent. of lead or zinc minerals. These minerals are generally conspicuous and as they form a considerable part of the volume of a base-metal ore it is usually possible, without chemical analysis, to form a fair idea as to whether or not a mineralized material contains ore mineral in quantity which approaches or exceeds the minimum required for ore.

Silver minerals (as grey copper, ruby silver, argentite) are usually recognizable if the silver content approaches or exceeds commercial grade.

Gold may or may not be visible to the naked eye. However, if gold ore contains very little or even a moderate amount of sulphide minerals some gold is often recognizable if the material approaches commercial grade. If the mineralization contains a substantial percentage of sulphides, gold is apt to be at the margins of sulphide grains or enclosed in them and therefore to be inconspicuous. For either type of ore only assaying will give accurately the gold content of samples, but less precise information obtainable in the field may be of great value to the prospector, particularly as it can be obtained in remote localities and with very little delay.

If the gold particles can be freed from the other material it is possible to wash away most of the other material, using a gold-pan, a large spoon, or a frying-pan. Whatever is used must be entirely free from grease, and should be heated to redness in the fire to burn off grease if any is present.

An experienced man can form a fair idea of the gold content of ore by estimating closely the amount of ore with which he starts, and equally closely estimating the amount of gold which he is able to separate.

To be of commercial interest for its gold content alone, ore must contain several dollars' worth of gold per ton. If free gold in grains of some size can be seen in the ore, or in concentrates panned from a crushed sample, the deposit warrants careful study. If from one-half pound of ore careful panning recovers a few tiny colours the prospects are less attractive. One-half pound is one four-thousandth of a ton, and for ore to run $5 per ton one-half pound would contain one-eighth of a cent. This would be 12 colours if they ran 100 to the cent, or 125 colours running 1,000 to the cent. A single small grain might well weigh more than the considerable number of fine

* "Elementary Geology Applied to Prospecting," by John F. Walker, price 35 cents, is available from the Department of Mines, Victoria, B.C.

colours. In estimating the quantity of gold it is found useful to count the colours and to compare their size with those obtained in other pannings.

Weights and values of grains of gold of different sizes are listed in the table on page 12 and the estimation of gold in test-panning placer deposits is discussed on pages 11 and 12. It is unlikely that panning crushed samples will permit a close estimate of the grade of ore, but it can indicate whether mineralization contains enough gold to be of interest. The results obtained in this way need not be regarded as final; samples of promising mineralization should be sent in for assay even if testing in the field fails to indicate gold in important quantity.

The quantity of ore to be tested for gold must be broken into small pieces and then ground to a fine powder. Roasting the small pieces, spread thinly in a can or other container over a fire, before grinding will make the grinding easier if the ore contains a fair amount of sulphides. If the gold is closely associated with sulphides it will be best to carry on the roasting in such a manner that the sulphides are oxidized as completely as possible. Alternate roasting and crushing or grinding may be easier and will give more complete oxidation. Roasting fine sulphides mixed with soda may be necessary to break down some material completely. The last stage before the actual washing should be grinding. For this purpose a mortar and a pestle are required, cast iron ones can be bought, or a 2-inch pipe cap and the hammer-end of a prospector's pick can be used as a substitute.

Panning gravel or soil from creeks or side-hills, or the decomposed material from outcrops, is a well established and extremely useful procedure in prospecting, often making it possible to trace gold colours or other heavy minerals to their source in a lode deposit. In much of the country five or more small colours in a pan warrant careful search for the deposit which is the source of the colours. Concentrating the heavy minerals by panning makes it possible to detect a few small particles of gold or of other heavy minerals which could not possibly be detected when mixed with a large quantity of gravel, sand, or soil.

In general, the small heavy particles will be most easily found if the panning is carried to the point where only the heaviest material remains in the concentrate, but in order to obtain the maximum information it is desirable that minerals of intermediate specific gravity be retained in pan concentrates which are sent to the laboratory for study. With these thoughts in mind, it is suggested that when a prospector wishes to send in concentrates he should divide them into two parts when he has panned to the point where material of intermediate specific gravity (grey sands) begin to be washed out of the pan. The one part should be allowed to dry, then put in a suitable container (bottle, tight tin, or strong paper bag), properly labelled and a record made. The other part can be studied by the prospector and then panned down to black sand for final study.

In studying the pan concentrates the prospector will find a magnifying-glass useful. Study under ultra-violet light* will reveal scheelite or zircon if present in important quantity. Study of pan concentrates may give very useful information in prospecting for lode deposits. Angular gold, particularly if still attached to quartz, has probably not travelled far from the vein where it originated, while rounded grains of gold have probably travelled a long way from their source.

Cassiterite (tinstone), wolframite (an ore of tungsten), tantalite, and certain other dark minerals are difficult to identify in pan concentrates. Their presence would become apparent if the concentrates were tested in the laboratory. Further, there is a possibility that in the laboratory study other facts may become apparent and may be of use in prospecting. For these reasons it is recommended that from time to time a quantity of pan concentrates, including material of intermediate specific gravity, be sent to the laboratory to be sure that no important information is being overlooked.

* Many minerals show characteristic colours (fluoresce) when exposed to the ultra-violet lamp. Some common minerals with their fluorescent colours are as follows: Scheelite, bluish-white to pale yellow; zircon, orange-yellow; some calcite, reddish; white encrustations of lime, pink; secondary zinc carbonate, white.

INSTRUCTIONS REGARDING SPECIMENS AND SAMPLES TO BE SENT TO THE LABORATORY OF THE DEPARTMENT OF MINES.

(Labelling, Recording, Packaging, and Shipping.)

Before it will do assaying the laboratory of the Department of Mines requires that the prospector submitting samples shall have made application for free assaying and shall inform the laboratory from what locality the samples were obtained. Further, the laboratory will not do work on samples or specimens which are not individually identified. Therefore the shipper should make sure that every sample or specimen which he sends in is identified by an individual number or other symbol on a tag or slip of paper accompanying the specimen or sample, and that the tag or slip of paper has on it clear instructions that he wants the rock or certain minerals determined, or a sample assayed for certain metals, or that he wishes to know whether or not it contains anything of value. The practice of ringing, with crayon, the parts of a specimen containing a mineral to be determined, and of actually selecting loose grains of mineral or of material from pan concentrates, will remove any doubt that it is the desired mineral which is being determined.

To avoid confusion and in order that essential information shall not be forgotten, a precise written record of each specimen or sample should be kept for the prospector's own use. The record should include the number or other symbol used to identify the specimen or sample and should include most of the following information:—

> The date; the place; the nature of the material represented; its relation to other rock near-by; the purpose for which a specimen is taken; and, for samples, the width sampled, the position from which each sample was taken, and the metals for which it is to be assayed.

If several specimens or samples are taken it may be advantageous to make a sketch showing the position of each relative to the others, to the workings, and to the boundaries of the mineralized body from which each was taken. If several people are working together the name of the person who took each sample or specimen should also be recorded. As the best possible record of the nature of a specimen it is well, in addition to the written record, to keep a duplicate specimen, properly labelled.

For the convenience of prospectors the Department of Mines now issues specimen or sample tags, stapled together in booklets of ten sheets, with a cover giving directions for their use. Each sheet is printed on special strong water-proof paper. *Bona-fide* prospectors may obtain these booklets, free of charge, from any Gold Commissioner, Mining Recorder, or Sub-mining Recorder.

Each sheet of the booklet consists of two identically printed halves, separated by a line of perforations. The sheets are numbered serially; both halves of a sheet bear the same serial number. One sheet should be used for *each* specimen or sample. When taking a specimen or sample, both the upper and the lower halves of the sheet should be filled in. The upper half is retained by the prospector as his own record, to refer to when he receives the laboratory report; the lower half, properly filled in, is torn off at the perforations, folded so as to protect the writing, and enclosed with the sample or specimen being sent to the laboratory.

The number on the tag serves to identify the specimen or sample, since no two tags issued by the Department of Mines bear the same number. If the tag is properly filled out no covering letter need be sent to the laboratory for that particular specimen or sample. The tag should be filled out in the following way: Whether a specimen or a sample, fill in name, address, submitter's mark (if any), date, district, property, and locality. The remaining information required on the tag depends on whether the material is a specimen or a sample. *If a specimen*, ignore the "Width sampled" space, and the "Assay for" space. In the "Remarks" space state that the material is a specimen, and state the purpose of sending the specimen—e.g., describe the minerals

you want identified. *If a sample*, state the "Width sampled" if the sample is taken across a given width, but if just an indicator sample state that; state what metals to assay for, and use the "Remarks" space if such is required to describe further what sort of laboratory examination is wanted. On page 18 is a copy of a sheet properly filled out for a specimen, and on page 17 is one properly filled out for a sample.

If any prospector does not wish to use these specimen and sample tags he should be sure that he keeps an equivalent record in a note-book, that each specimen or sample sent to the laboratory is accompanied by a slip of paper on which he has written the identifying number or other symbol and the mineral determination or the assay desired. The name and address of the sender must be on a slip of paper in the package, and the sender must also send a letter to the laboratory, stating the locality and property from which his samples or specimens were obtained and what determinations and assays are desired. The letter must be sent separately, as inclusion of a letter in a parcel is contrary to postal regulations.

With samples or specimens properly labelled, each specimen individually wrapped, and each sample enclosed in a clean strong cotton or paper sack, the specimens or samples to be sent to the laboratory should be strongly wrapped in paper or enclosed in a sack or box and sent prepaid by mail or express to:—

The Chief Assayer,
Department of Mines,
Victoria, B.C.

The Department supplies printed shipping tags with the proper address printed on them. These tags can be obtained free by *bona-fide* prospectors from the Department of Mines at Victoria, or from any Gold Commissioner, Mining Recorder, or Sub-mining Recorder in the Province.

On request made to the Department of Mines, Victoria, a limited number of sample sacks will be loaned to *bona-fide* prospectors free of charge.

DEPARTMENT OF MINES.

No 2482

SPECIMEN OR SAMPLE TAG.

Taken by John Doe

Address Kelly Lake P.O.

Submitter's mark (if any)

Date Aug. 17, 1943

District Upper French Bar Creek.

Property and locality Bonanza Claim, 3 mi N.W. Swan Lake; north end of cut, 100 yd. W of cabin

Width sampled 3 ft. full width of vein

Assay for Gold & Silver

Remarks Quartz mineralized with pyrite

DEPARTMENT OF MINES.

No 2482

SPECIMEN OR SAMPLE TAG.

Taken by John Doe

Address Kelly Lake P.O.

Submitter's mark (if any)

Date Aug. 17, 1943

District Upper French Bar Creek.

Property and locality Bonanza Claim, 3 mi. N.W. Swan Lake; north end of cut, 100 yd. W of cabin.

Width sampled 3 ft. full width of vein

Assay for Gold & Silver

Remarks Quartz mineralized with pyrite

DEPARTMENT OF MINES.

Nº 2483

SPECIMEN OR SAMPLE TAG.

Taken by John Doe

Address Kelly Lake P.O.

Submitter's mark (if any)

Date Aug. 18, 1943

District Upper French Bar Creek

Property and locality Bonanza Claim, 3 mi NW Swan Lake; south end of outcrop 200 yd. W. of cabin

Width sampled

Assay for

Remarks Specimen, from quartz vein, determine dark mineral ringed with blue crayon.

DEPARTMENT OF MINES.

Nº 2483

SPECIMEN OR SAMPLE TAG.

Taken by John Doe

Address Kelly Lake P.O.

Submitter's mark (if any)

Date Aug. 18 1943

District Upper French Bar Creek.

Property and locality Bonanza claim, 3 mi. NW. Swan Lake; south end of outcrop, 200 yd. W. of cabin.

Width sampled

Assay for

Remarks Specimen, from quartz vein, determine dark mineral ringed with blue crayon

PART II.

THE LABORATORY TREATMENT OF SPECIMENS AND SAMPLES.*

RECEIPT OF SPECIMENS AND SAMPLES AT LABORATORY AND LABORATORY RECORDS.

When a package of samples or specimens is received at the Department of Mines laboratory in Victoria, it is opened (*see* Plate 1A) and each sample or specimen is put in a separate tray and given a serial number from a printed assay check book. Each sheet in this book consists of a detachable tag bearing a printed number and a stub bearing the same number. On the stub a note is made of the date of receipt, the name and address of the sender, and the identifying number or letter he has used for the sample. It is on this stub that the mineralogists and analysts write the results of their work. During the course of the laboratory examination each sample is known only by its serial number.

STUDY OF SPECIMENS.

Specimens are examined by a mineralogist with sufficient care to answer questions asked by the sender in his accompanying letter or sample tag. The first step is study of the non-fluorescent minerals present with a hand-lens, followed by study under an ultra-violet lamp to see whether any fluorescent minerals (such as scheelite) are present. This is often sufficient in the case of common rocks and minerals, but in the case of some rocks and minerals a thorough microscopic examination is necessary.

Use of the microscope makes possible the identification of the less common minerals and also makes the association of minerals clear. In this microscopic examination a rock-forming mineral is ground to a powder and the fragments examined, or a very thin slice of rock is cut to study not only the individual minerals but the relationship between them; such a slice is known as a "thin section" (Plate 1B).

In the case of ore minerals which are not transparent, a surface of the sample is ground and polished on a special polishing-machine; this is the treatment given to sulphide minerals when particularly careful study is called for. Plate 1C shows such a polished surface mounted in bakelite.

Plate 2A shows what a thin section of rock may look like under the microscope, when magnified 30 times. Notice how the crystal structure is clearly shown. Plate 2B shows what a polished surface of metallic minerals may look like under a microscope, when magnified 19 times. Plates 2C and 3 show some of the microscopic equipment used in examining samples and specimens.

The sender usually wants his specimen classified; that is, he wants it named. He may also want all the information he can get concerning the nature of the deposit from which it was obtained. The mineralogist identifies the specimen, and from experience in the field and knowledge of the geology of the district from which the specimen came can usually supply information about the deposit or formation from which the specimen came. This is one of the reasons why the laboratory requires information on the locality and district from which the specimen or sample came.

The laboratory report sheet, sent to the submitter of a specimen, lists the minerals determined or gives the name of the rock, and gives the available information concerning the deposit or formation from which the specimen was obtained.

PREPARATION AND ANALYSIS OF SAMPLES.

(a.) MINERALOGICAL DETERMINATION.—Each sample, before crushing, is examined by a departmental mineralogist to determine the character of the mineralization and to

* By G. Cave-Browne-Cave, Chief Analyst and Assayer.

indicate the valuable minerals present as a guide to analysis; and also to classify as well as possible the deposit from which the sample comes, in case reference is made to it in the future. The sample is examined with a hand-lens and is also studied under ultra-violet light, and the conclusions are given to the analyst. This mineralogical examination is merely the starting-point for samples which are submitted for assay.

(*b.*) ANALYST'S EXAMINATION.—Following the mineralogical examination, the Chief Analyst examines the sample. Taking into account the specific requests the prospector makes in his covering letter or sample tag, and the results of the mineralogical examination, he decides what laboratory-work should be done on the sample. The sample is then handed to the crusherman to prepare.

(*c.*) CRUSHING THE SAMPLE.—After drying, if necessary, the entire sample is crushed in a jaw-crusher to particles about the size of dried peas or smaller (Plate 4A). This crushed sample is thoroughly mixed and then divided by riffling, to decrease its bulk, using a Jones riffle (Plate 4B). The smaller sample so obtained is then ground to a very fine powder in a disk pulverizer (Plate 5). This powder is divided into four parts. One part is kept on file for three months. One part goes to the fire assay laboratory for precious metal assays. One part goes to the spectrographic laboratory for a complete analysis of base metals, and the fourth part goes to the wet laboratory for base-metal assays.

(*d.*) SPECTROGRAPHIC ANALYSIS.—With the installation in 1941 of a modern grating spectrograph and accessories, the laboratory increased immeasurably the service it could render to prospectors. With this instrument it is possible to make a rapid and complete analysis of a sample for the base metals. The method is very rapid and, despite the apparent complexity of the apparatus, there is absolutely no uncertainty about the results of such an analysis. Plate 6 shows the main spectrographic installation. .

A detailed discussion of the principles of spectrographic analysis lies outside the scope of this bulletin, but a brief discussion of how an analysis is performed is appropriate. A weighed portion of the powdered sample is placed in a pure carbon cup (Plate 7A). This cup is then inserted into a vertical carbon rod, forming one pole of an electric arc (Plate 7B). Another pure carbon rod forms the other pole of the arc and is clamped so that ½-inch air-gap separates it from the carbon cup holding the sample. Both carbon rods are connected to an appropriate source of electricity. When the arc is "struck," electricity flows continuously across the ½-inch air-gap from one carbon rod to the other. A temperature of over 4,000 degrees Fahrenheit is created thereby and the tips of the carbon rods become white hot (Plate 7C). The heat is so intense that it not only melts, but actually vaporizes all the powdered sample contained in the carbon cup, no matter what elements the sample may contain. Depending on various factors, it takes between one and three minutes for the entire rock sample to vaporize in the electric arc. While in the arc-gap, the gaseous metals of the sample emit light of various colours or, to be exact, of various wave-lengths. Each metal emits its own characteristic group of colours, or wave-lengths, and no other metal ever duplicates this group exactly. The light enters the spectrograph, is there analysed, and exposes a photographic film forming a series of lines corresponding with the colours emitted. When developed, this film is called a spectrogram, and shows many thin vertical black lines along its length (Plate 8A).

Spectrographic analysis is possible because each metal always produces a certain group of black lines on the photographic film, at certain fixed positions, and no two metals produce the same group of lines. Knowing where the lines of each metal occur on the film, study of the proper part of the film tells whether a certain metal is present or not. Examine Plate 8B. It shows portions of three spectrograms. The upper one is of pure zinc. The lower one is of pure cadmium. The middle one is of a prospector's ore sample. Notice how the zinc lines in the uppermost spectrogram

coincide exactly with lines in the middle spectrogram. We know, then, that zinc is present in the prospector's sample. Likewise the cadmium lines in the lowest spectrogram coincide exactly with lines in the middle spectrogram. Hence cadmium is present also. Actually such comparisons are made by magnifying and projecting the spectrogram on to a screen. Plate 8C is a close-up of part of the actual screen with part of a spectrogram of a rock shown in the upper half of the picture and with part of a "master plate" projected and shown in the lower half. This master plate has marked on it the sensitive lines of all the metals in their correct places. The part shown has a molybdenum (Mo), a tin (Sn), and three vanadium (V) lines. The upper half of the picture has lines coinciding exactly with these molybdenum, tin, and vanadium lines on the master plate. Hence these metals are present in the prospector's sample. Other molybdenum, tin, and vanadium lines exist in other parts of the spectrogram but are not shown here. The instrument used to magnify and project spectrograms is shown in Plate 9.

The positions of the black lines in a spectrogram tell what metals are present (qualitative analysis). By measurement of the exact blackness of the lines the percentage of a metal in a sample can be determined (quantitative analysis). The instrument shown in Plate 9 is also used to measure this blackness. It contains a photoelectric device which permits exact measurement of the blackness of any line.

An important feature of the spectrographic method is its extreme sensitivity. It will detect metals present down to between 0.01 per cent. and 0.0001 per cent. (between one one-hundredth and one ten-thousandth of 1 per cent.) of a metal in a sample, depending on the metal. It is only in particular work such as crime detection and the analysis of smelter products that the detection of such minute percentages is of value, and to the prospector and field engineer they are of no significance whatever in the present state of our knowledge of geology. Such low percentages, even when measurable, are considered as "traces" when reporting on samples from the field.

In addition to metals present in higher percentages most samples sent in by prospectors contain ten to fifteen metals as spectrographic traces; that is, in quantities so small that they can be of no possible commercial value. It would merely be confusing if a report were issued listing all these trace metals. Consequently they are not given in the usual laboratory report. Instead the report on the spectrographic analysis may merely read "a complete analysis for all base metals showed none of interest." If such a report is received, the prospector can be assured that there are no base metals of possible economic interest in his sample. There is no possibility that the spectrograph has failed to show an important amount.

The spectrograph is not used generally to detect the precious metals in a rock sample. One important reason is that, while base-metal minerals can readily be crushed to fine powders, and consequently a quite representative sample taken for spectrographic analysis, the precious metals, such as gold, will not grind into a fine powder but will merely roll up into a ball. Hence a large weight of powdered sample is needed for analysis to represent the sample accurately. Such a weight (about one-half ounce) is too large for the spectrograph. Consequently, precious metal detection and assaying is done by the fire assay method.

If the spectrographic analysis shows that the sample contains certain base metals in percentages that might be of value the sample is sent to the wet laboratory, where the percentages of these metals are determined exactly.

(*e*.) WET LABORATORY.—This laboratory is equipped with the elaborateness necessary to determine accurately the percentage of any element in a sample. The term "wet" assay is used to indicate that the percentage of metal in a sample is determined by using acids and solutions of other chemicals.

It is not possible to describe the methods of analysis in detail, but the method used for determining the percentage of zinc in a sample is outlined below. This outline involves some of the more usual operations an assayer performs in wet assaying.

A precise amount of the pulverized rock sample is weighed on a balance (Plate 10A). This weighed sample is placed in a glass beaker and acids are added. On heating, most of the metallic minerals, including the zinc minerals, decompose and are dissolved by the acids (Plate 10B), and a solution containing zinc and other metals results. The next step is to separate these other metals, such as iron, manganese, copper, etc., from the zinc. To accomplish this the assayer adds to the solution certain chemicals which precipitate the unwanted metals as solids but leave the zinc in solution. The next step is to separate these solids from the clear zinc solution, by filtration. Plate 11 shows the mixture of solids and zinc solution being filtered. In this step the mixture is poured into a cone-shaped filter-paper which retains the solids but allows the solution, containing all the zinc, to pass through and be collected in a beaker.

Thus purified, the zinc solution is then brought to a definite acidity and temperature, and is then ready for the final step—that of "titration." Plate 12A shows this operation. A solution of known concentration of a chemical called potassium ferrocyanide is added slowly to the zinc solution, and combines with the zinc to form a solid which is precipitated. The potassium ferrocyanide is added until all the zinc has been precipitated, and a change in colour of an "indicator" solution tells accurately when this point has been reached. The exact volume of potassium ferrocyanide added is measured, from this measurement the assayer can at once calculate how much zinc was in the solution. Then he can readily calculate the percentage of zinc in the rock sample. In similar ways the percentages of copper, lead, iron, tungsten, or other metals in the sample are determined. However, each determination is a separate undertaking, and starts with its own weighed quantity from the pulverized sample. Plates 12B and 13 show other operations in wet assaying and analysis.

(*f.*) FIRE LABORATORY.—The fire assay method is used to determine the number of troy ounces of precious metals (gold, silver, platinum, iridium, osmium, palladium, rhodium, and ruthenium) per ton of ore. The methods used differ radically from those in the wet laboratory.

A precise amount of pulverized sample is weighed out and mixed with certain dry chemicals called fluxes. Lead oxide is added and if the ore has not a sufficient reducing power of its own, flour is also added as a source of carbon. The entire mixture is then placed in a fireclay crucible (Plate 14), put in a furnace, and brought to a temperature of about 1,800 degrees Fahrenheit for about one-half hour (Plate 15). On heating, the fluxes combine with the rock and form substances that melt readily; the entire mixture is a liquid after about thirty minutes in the furnace.

During this half-hour heating period, the lead oxide and carbon react to form metallic lead. The molten lead, being heavy, falls through the liquid mixture of sample and flux like a shower of rain, and as it falls it amalgamates with (dissolves) all the precious metal particles in the sample. When time has been allowed for all the lead to collect as a liquid on the bottom of the crucible, the crucible is taken from the furnace and the molten contents poured into an iron mould to cool, as in Plate 16. The lead sinks to the bottom of the mould, beneath the lighter rock-flux liquid which is called "slag." When solidified the lead exists as a cone-shaped button attached to the slag, as in Plate 17A. The lead button is broken away, hammered into a cube, and brushed well to remove adhering particles of slag, and the slag is thrown away, for all the precious metals have now been extracted from it.

The lead button (Plate 17B), which contains all the precious metals that were in the sample, is then put in a hot "cupel" in a furnace at about 1,200 degrees Fahrenheit (Plate 18A). The lead melts, and on the upper surface combines gradually with the oxygen in the air to form liquid lead oxide. This liquid lead oxide rolls off the molten lead and is absorbed by the cupel until all the lead has been oxidized and absorbed. The precious metals on the other hand do not oxidize, and are not absorbed by the cupel. They remain on the surface of the cupel as a round, shining bead (Plate 18B), which contains all the precious metals present in the sample.

The bead is carefully removed from the cupel, after cooling, and is brushed and then weighed. The bead is next treated with hot acid to dissolve the silver and leave the gold, which is not affected by the acid. The gold is well washed, dried, and weighed on a very accurate balance (Plate 19) which is sensitive to 1/15,000,000 ounce. Then a simple calculation gives the amount of both gold and silver present in the sample, in terms of troy ounces per ton. Usually about ½ oz. of ore is taken for assay; from this a gold bead about the size of a pin-head represents about 10 oz. of gold per ton.

The presence of members of the platinum group is indicated by the appearance of the bead and by its behaviour with hot acid. Special methods are needed for the separation of metals of the platinum group from each other.

THE LABORATORY REPORT.

DESCRIPTION OF THE REPORT.—The results of examination and analysis are entered on a laboratory report and sent to the person who submitted the sample. In many instances the information on this report is self-explanatory, but it is worthy of discussion here so that there need be no misinterpretation.

A typical example of a laboratory report is given on page 24. In the first column is the laboratory serial number assigned to the sample when it is received in the laboratory. In the second column is the identifying number or letter the prospector gave to his sample; where a Department of Mines sample tag has been used, its serial number will be quoted here. In the third column is the laboratory report proper. It consists first of the results of the mineralogical examination. The rocks and minerals are mentioned: "Fine-grained altered granite with veinlets of calcite; some galena and sphalerite; some fluorescent specks." There may also be scattered grains of other minerals which will not have been recognized unless the sample was studied microscopically. To this extent the mineralogical examination may be incomplete, but the purpose of the mineralogical examination of a sample is to give the prospector a general picture of the type of rock with which he is dealing, and is not intended to be an exhaustive study. The fact that "fluorescent specks" were observed does not prove the presence of scheelite. A few other common minerals, such as hydrozincite, fluoresce.

The "Spectrographic Analysis" shows lead, zinc, and cadmium to be the only *base* metals of interest. This means that although there were probably between ten and fifteen trace metals, only lead, zinc, and cadmium could conceivably be of economic interest. Analyses for the precious metals are not made spectrographically and consequently these are not listed.

The "Assays" give the precise percentages of lead, zinc, and cadmium as reported by the wet laboratory after the analysts there had been informed that the spectrographic analysis showed that these metals were present in percentages sufficiently high to warrant accurate assays. The results of the fire assay indicate the presence of 0.63 oz. per ton of gold (63/100 oz.) and 5.1 oz. per ton of silver.

Occasionally the laboratory report gives not only a base-metal assay requested by a prospector but also gives one or more assays on impurities in the ore. Thus phosphorus and sulphur assays are usually given along with an iron assay on iron ore. The reason is that base metal deposits cannot be evaluated on the basis of the value of the chief base metal alone. Amongst other things, certain impurities may be detrimental; and, indeed, if the percentages of these impurities are high enough, may cause a smelter to refuse to handle the ore. Thus phosphorus and sulphur in iron ore; selenium in antimony ore; magnesium, iron, and insoluble matter in limestone; molybdenum in tungsten ore; to name only a few, are detrimental if above certain percentages, usually quite low.

CALCULATION OF MONEY VALUE OF ORE FROM LABORATORY REPORT.—The percentage of each metal is given in the report, but the value of the metals is never given, because the gross value of contained metals is not the real value of any ore, to the man who mines it or to any one else. Whether an ore is shipped to a smelter or milled on the

OFFICE OF THE CHIEF ANALYST
AND ASSAYER

THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF MINES
VICTORIA

SAMPLE RECEIVED FROM John Doe, Esq.,

ADDRESS Green's Corner P.O., B.C.

LABORATORY NO.	SUBMITTER'S MARK.	LABORATORY REPORT.
1012 B	# 1	<u>Mineralogical Determination:</u> Fine-grained altered granite with veinlets of calcite; some galena and sphalerite; fluorescent specks. <u>Spectrographic Analysis:</u> A complete analysis for all base metals showed none of interest, except lead, zinc, and cadmium. <u>Assays:</u> Gold 0.63 oz./ton Silver 5.1 oz./ton Lead 1.6 % Zinc 9.3 % Cadmium 0.2 %

DATE January 27th, 1944.

CHIEF ANALYST AND ASSAYER

property, or both, a percentage of each metal is lost in the treatment process, the amount varying with the method of treatment and the type of ore. Further, one metal in the ore of another may not only be lost in the process but may make smelting more difficult. For this reason no payment is made by smelters for zinc in lead ore, and for many years an extra charge was made for smelting lead ore if zinc were present in excess of a moderate percentage. The case of zinc or arsenic in a copper ore is similar. There are also freight and treatment charges, which reduce the gross value of the ore.

To illustrate the difference that exists between gross and net values on ores, the following examples are given, using current British Columbia smelter rates (April, 1944):—

Example 1: A gold ore assays 0.50 oz. gold per ton. Gross value at the market price of gold, $38.50 per ounce, is $0.50 \times 38.50 = \$19.25$ per ton. The smelter pays for 95% of the gold at $38.50 less $1.02 per ounce; that is, in ore such as this example, it pays for $0.50 \times {}^{95}/_{100} = 0.475$ oz. at $37.48 or a net value of $17.80 per ton, from which the charge for smelting and the freight paid on the ore must be deducted.

Example 2: A lead ore assays 20% lead. 20% lead is 20 lb. of lead per 100 lb. of ore; i.e., 400 lb. of lead per ton of ore. The Canadian market price of lead is 3.362 cents per pound. Hence the gross value of the lead is $400 \times 3.362\text{c.} = \$13.45$ per ton. The smelter deducts 1.25% from the assay, and therefore pays for $(20\% - 1.25\%) = 18.75\%$ lead, which is 375 lb. of lead per ton of ore. It then pays for 92.5% of this 375 lb. at 2.112 cents per pound (3.362c. — 1.25c. per pound smelter deduction). 92.5% of 375 lb. is $92.5/100 \times 375 = 346.87$ lb. So the net value is $346.87 \times 2.112\text{c.} = \$7.33$ per ton. Charges for smelting (treatment) and for freight have still to be considered.

Charges for Treatment and Freight.—Freight charges vary with the value of the ore and treatment charges vary with the character of the ore and may be more or less than the base rate ($7 per ton for lead ore) depending on the content of substances that may make the smelting difficult or easy. It is a safe rule that no one should ship ore to a smelter before finding out what the charges will be on his particular grade and type of ore.

CONCLUSION.

It will be seen that as a matter of course a sample from a *bona-fide* prospector receives a complete examination in the Victoria laboratory. There is no chance that a metal is overlooked. A complete examination takes a longer time than does a single assay for any one metal. For this reason, laboratory reports of complete examinations may take a longer time (several days) than if assays for one or two specified metals were made.

If a prospector is not interested in a complete examination but merely wants his sample assayed for one or two or three metals he should state this in his covering letter or on his sample tag, mentioning specifically the metals in which he is interested. In this way time and money are saved and the Laboratory Report may then be made out within two or three days after the sample is received. Assays on certain rarer metals, however, may require more time, and during the height of the busy summer season laboratory reports on samples may not be forthcoming as rapidly as when there is no rush of work in the laboratory.

PART III.

THE PRINCE RUPERT SAMPLING PLANT.*

The Provincial Government ore sampling, purchasing, and assembly plant began operations in Prince Rupert in August, 1937. It is advantageously located with both rail and steamship facilities.

This plant was established to assist prospectors and small operators in shipping small lots of ore and thus to enable them to obtain funds for further developing their properties and to give them a livelihood in the meantime.

The services of the sampling plant in sampling, assaying, purchasing, and marketing ores is entirely free. The only costs charged against ore shipments are those of freight, haulage, and smelter charges which would be paid by the shipper if he shipped directly to the smelter.

There are many advantages to the small operator in shipping through the sampling plant, some of which are as follows:—

(1.) Smelters usually make set charges for handling small lots of ore. These charges are reduced by combining at the sampling plant a number of small lots from several shippers.

(2.) Smelters charge penalties for various objectionable elements in ores purchased by them. These charges are often reduced or eliminated by mixing non-penalty ores with penalty-bearing ores at the sampling plant.

(3.) Smelters usually take about thirty days to make their first payment on the purchase of ore and in some cases do not make the final payment until ninety days after receiving the ore. The sampling plant makes full payment as soon as the assay results are obtained.

Preferential freight rates have been established on ore shipped to the sampling plant for both rail and water-borne shipments. Information regarding these rates may be obtained by writing to the Manager, Department of Mines Sampling Plant, Prince Rupert.

The sampling plant is prepared to accept ore for sampling in any quantity from a few pounds up to a car-load and will accept any number of shipments from a property while it is in the development stage. As soon as the property is in a position to make substantial regular shipments it is expected that they will be made direct to the smelter.

Should a prospector or operator decide that an ore deposit appears worth working, he should take a sample which is representative of the type of ore he wishes to ship and forward it to the Prince Rupert Assay Office. This sample will be assayed and from the results a "*pro forma* per ton calculation sheet" will be made out showing the exact smelter value of ore of this type and grade and the necessary charges and deductions which would be made against the ore. Finally the net return, after all charges are paid, will be shown. From this the operator will be able to determine whether the ore is of sufficient grade to pay him a profit after his mining and other costs are deducted.

All shipments made to the sampling plant for assay and test purpose should be forwarded freight prepaid.

When a shipper has a shipment ready to forward to the sampling plant he is advised to sample it carefully so as to obtain a sample which will be fully representative of the whole lot and to send this sample to the sampling plant. Should this sample prove to be of commercial grade, a "freight collect shipping permit" will be sent to the shipper and he can then forward his ore freight collect and have the freight charges paid by the plant and deducted from his settlement. This test sampling serves two purposes: It keeps the shipper from paying freight charges on ore which might not

* By T. Norton Youngs, Manager, Department of Mines Sampling Plant, Prince Rupert, B.C.

be of commercial grade and allows him to ship his ore without having to lay out money in advance for freight charges.

When a shipment of ore is received at the sampling plant it is crushed, carefully sampled by coning and quartering, and the resultant sample is assayed in the Prince Rupert Assay Office. Depending on the size of the shipment, the assay results are obtained in four or five days from the time the shipment reaches the plant. The necessary calculations are then made and the ore paid for at once.

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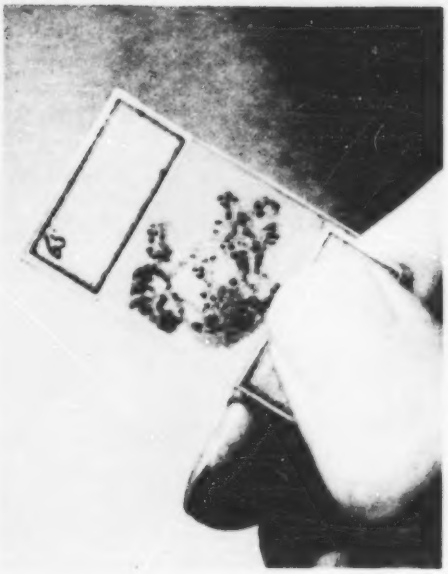
1944.

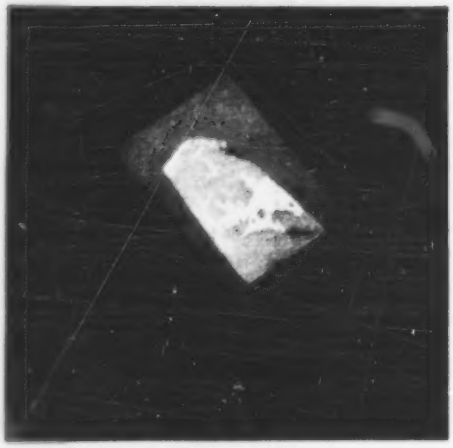
2M-644-9707

PLATE 1.

A.—A typical sample, properly packaged and labelled.

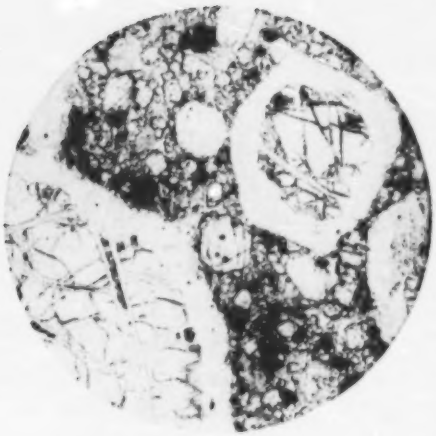


B.—A thin section of rock, ground to a thickness of about one one-thousandth of an inch and mounted on a glass slide for microscopic study.

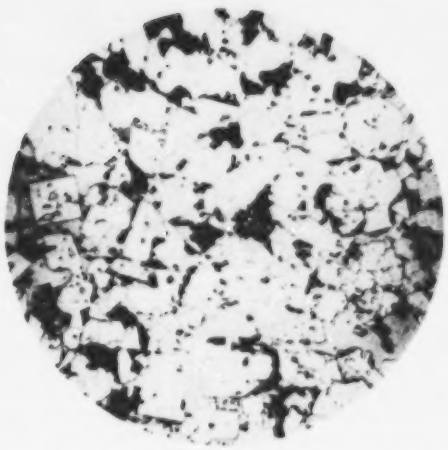


C.—A polished section of ore. The rock is mounted in a Bakelite cast, one surface of the rock given a high polish and examined microscopically to identify the ore minerals.

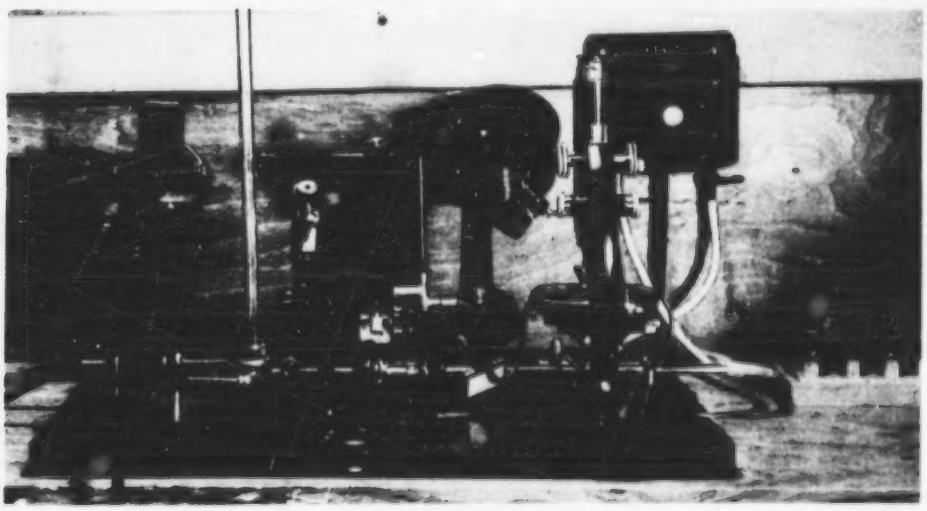
PLATE 2.



A.—A thin section of rock as seen through a microscope. Large grains are olivine, now altered around their rims and along fractures to serpentine (clear), and some magnetite (fine, black grains). The intervening material is a mixture of pyroxene (grains), serpentine (clear), and magnetite (black). Magnified thirty times.

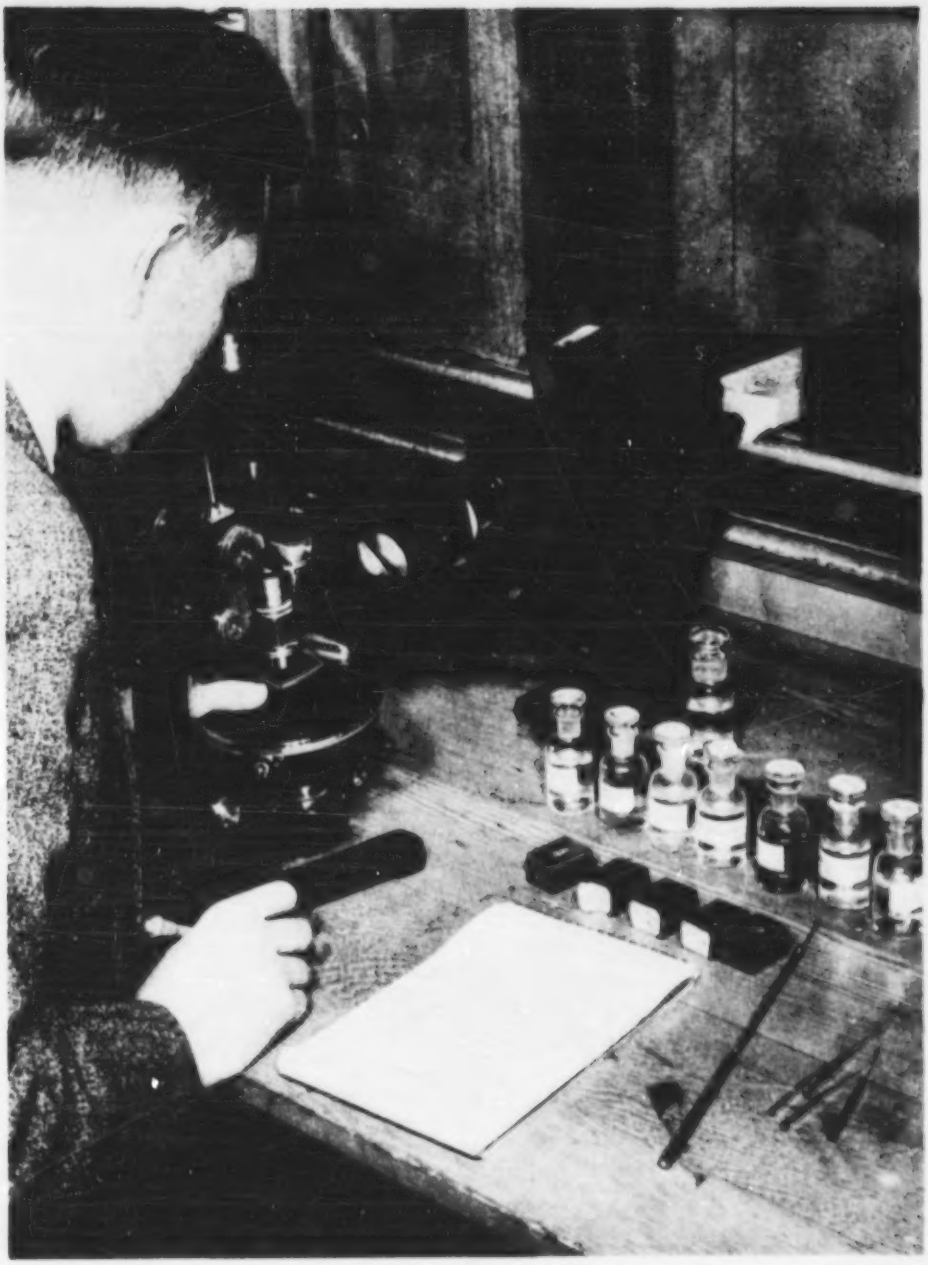


B.—A polished section as seen through a microscope. An intimate mixture of cubic pyrite (light grey grains), chalcopyrite (dark grey grains), and quartz (black areas). Magnified nineteen times.



C.—The Emmons double variation equipment. Used in the most precise work for identifying mineral grains microscopically.

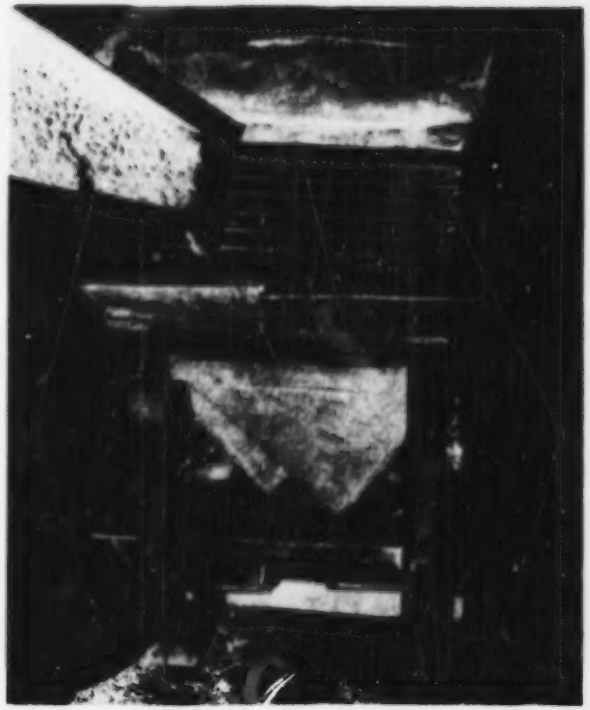
PLATE 3.



Examining a polished section (Plate 2B) under a microscope, using reflected light. The bottles on the right hold chemicals, a drop of which, when placed on the surface of a particular mineral on the polished section, gives a characteristic reaction by which the mineral can be determined.

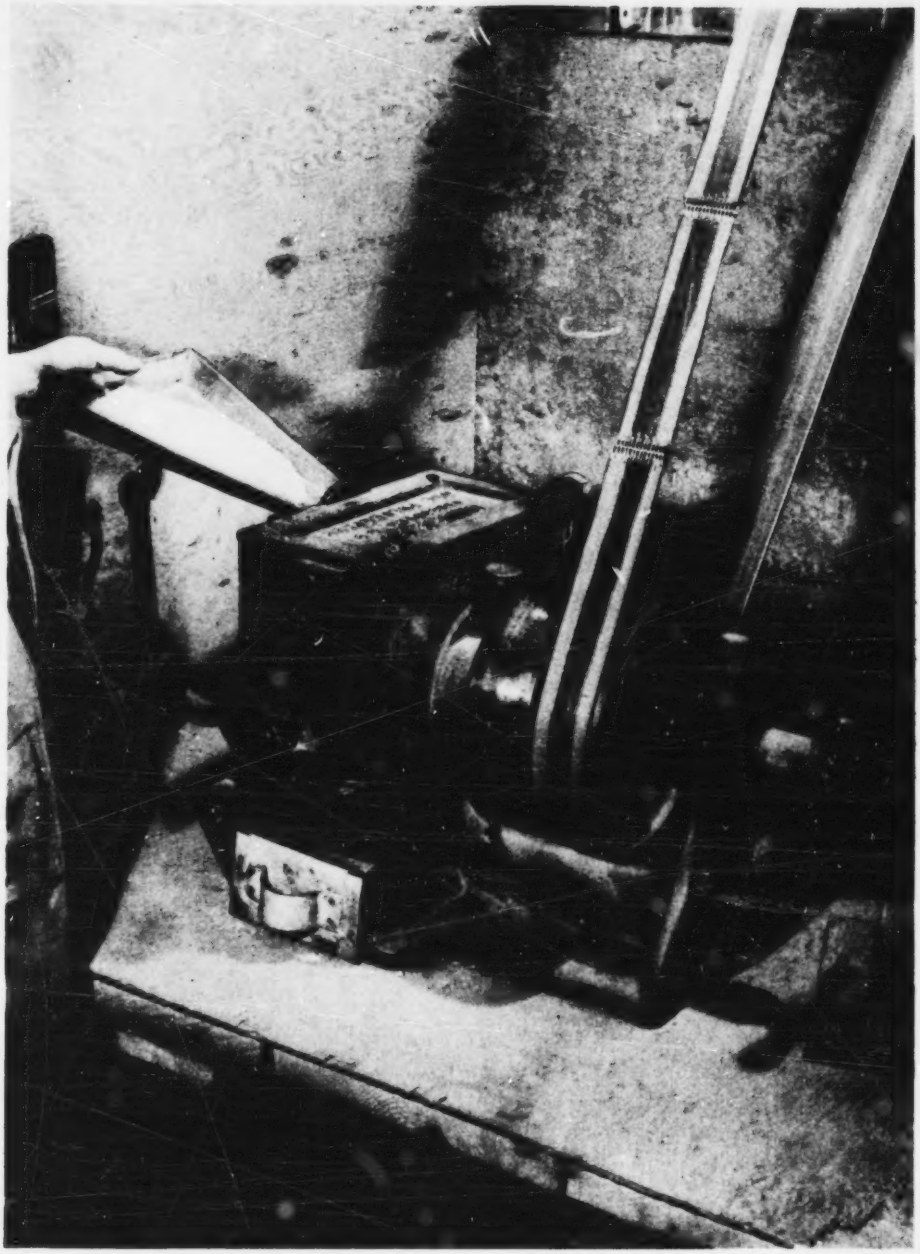
PLATE 4.

A.—Preliminary crushing of a sample in a jaw-crusher.



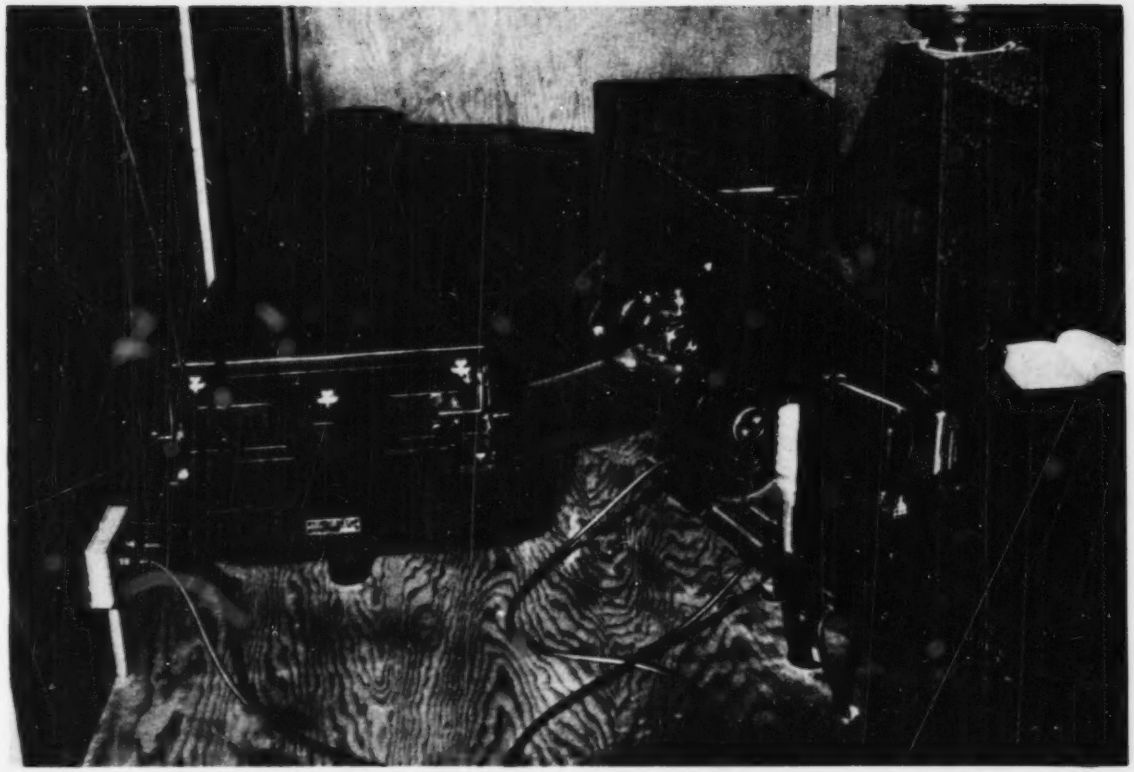
B.—After crushing the sample it is sampled in this Jones riffle, the falling ore being split into two streams by the metal partitions shown. One-half of the sample goes to the left-hand pan, the other half to the right-hand pan. The contents of either pan may be taken for further grinding and sampling.

PLATE 5.



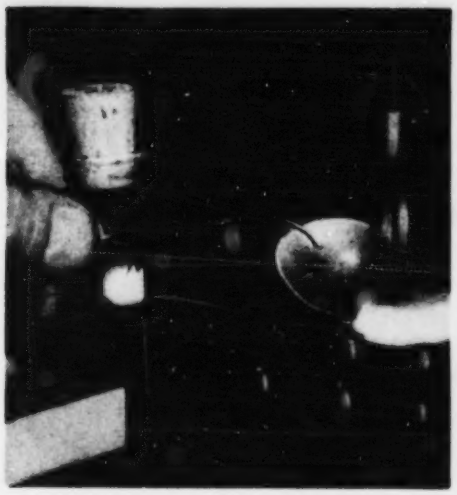
Grinding the crushed and sampled ore into a fine powder. The ore is fed in between two circular steel disks enclosed in the steel box. One of the disks revolves rapidly, thereby grinding the rock between the disks.

PLATE 6.

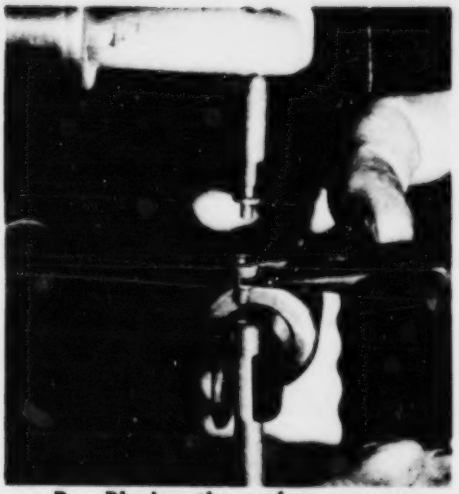


The spectrograph, an instrument to analyse and photograph the light emitted by incandescent metallic vapours. An electric arc produces these vapours from the powdered rock. The arc is enclosed in a wire cage shown on the right. The camera is on the left. The instrument is about 5 feet long.

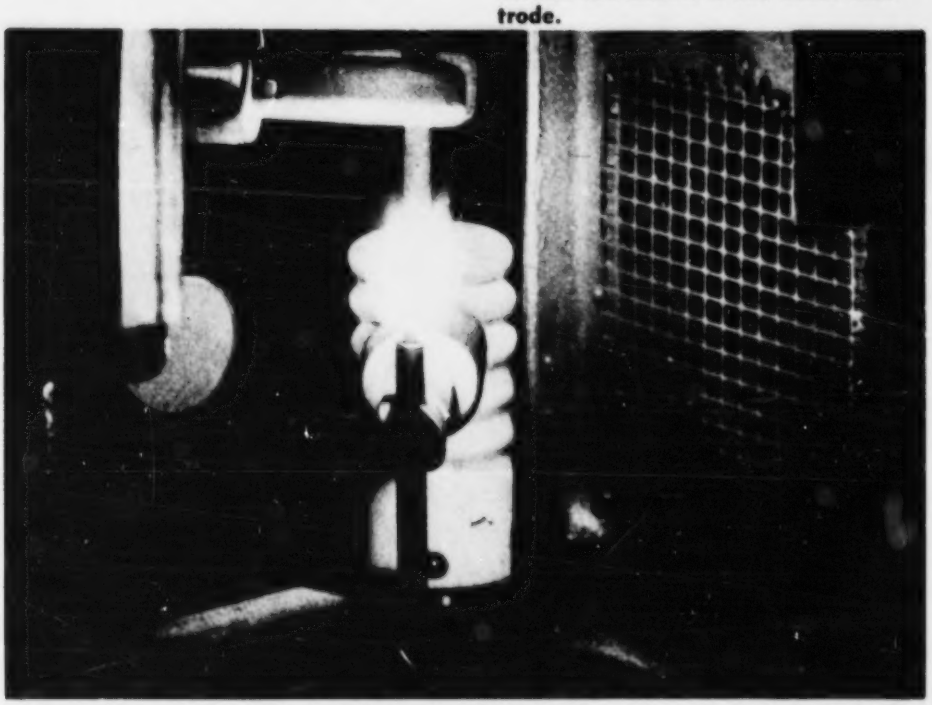
PLATE 7.



A.—Transferring weighed rock powder to a carbon cup for spectrographic analysis.



B.—Placing the carbon cup containing the rock sample in a carbon rod holder, which forms one electrode of an electric arc. The upper carbon rod shown is the other electrode.



C.—The carbon rods have been touched together, then separated one-half inch. Electricity is flowing across the gap, producing intense heat which is vaporizing the rock sample. Notice the light the arc emits. The spectrograph analyses this light.

PLATE 8.

A.—Part of a typical spectrogram. The light emitted by the arc (Plate 7C) has travelled through the spectrograph, thereby being dispersed into very narrow beams of light, which produced the fine black lines on the film.

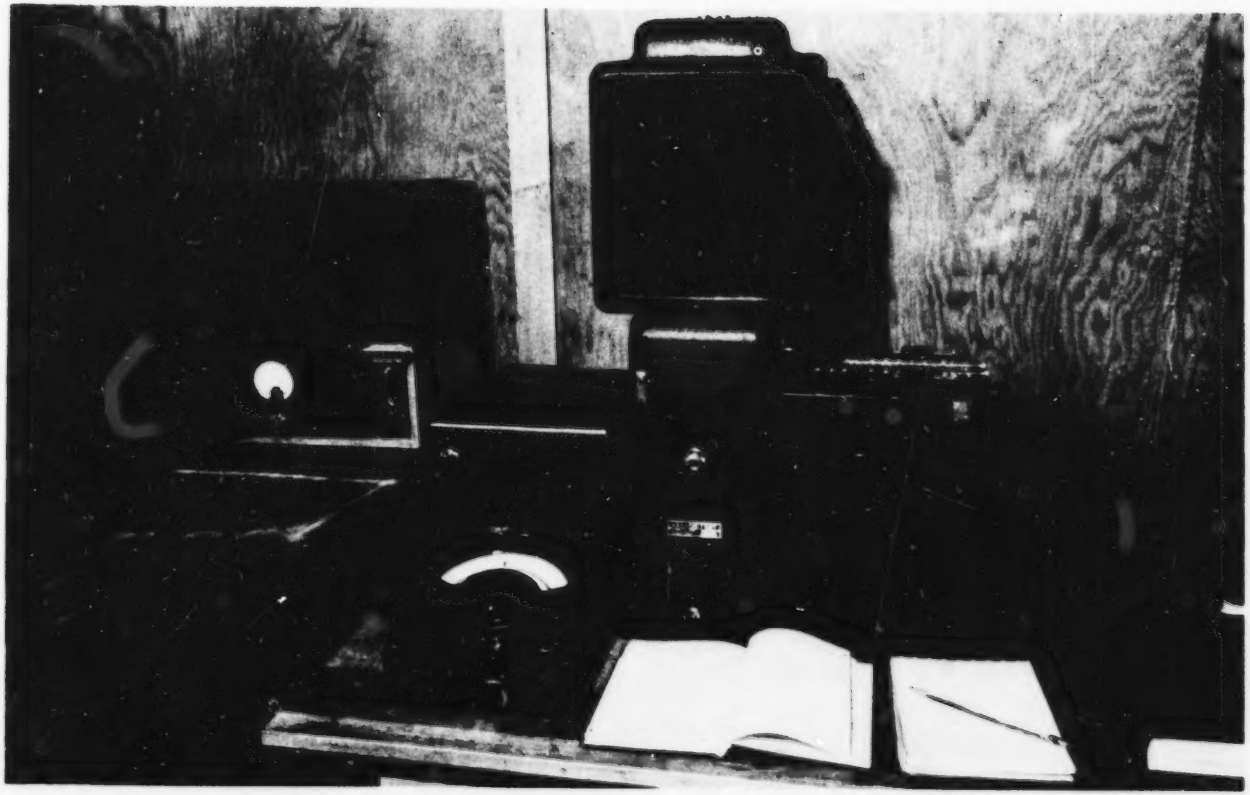
B.—Parts of three spectrograms. The upper one is of zinc, the lowest is of cadmium, and the middle one is of a prospector's sample. Both cadmium and zinc are present in his sample. The additional lines in the centre spectrogram are due to the presence of other metals in the prospector's sample.

← C.—Lines on a spectrogram of an ore containing molybdenum, tin, and vanadium.

Below the horizontal dividing line is a projected image of a master plate, on which occur ← sensitive lines of all metals. Here the molybdenum (Mo), tin (Sn), and vanadium (V) lines of the master plate are shown. Notice they coincide exactly with those of the ore.

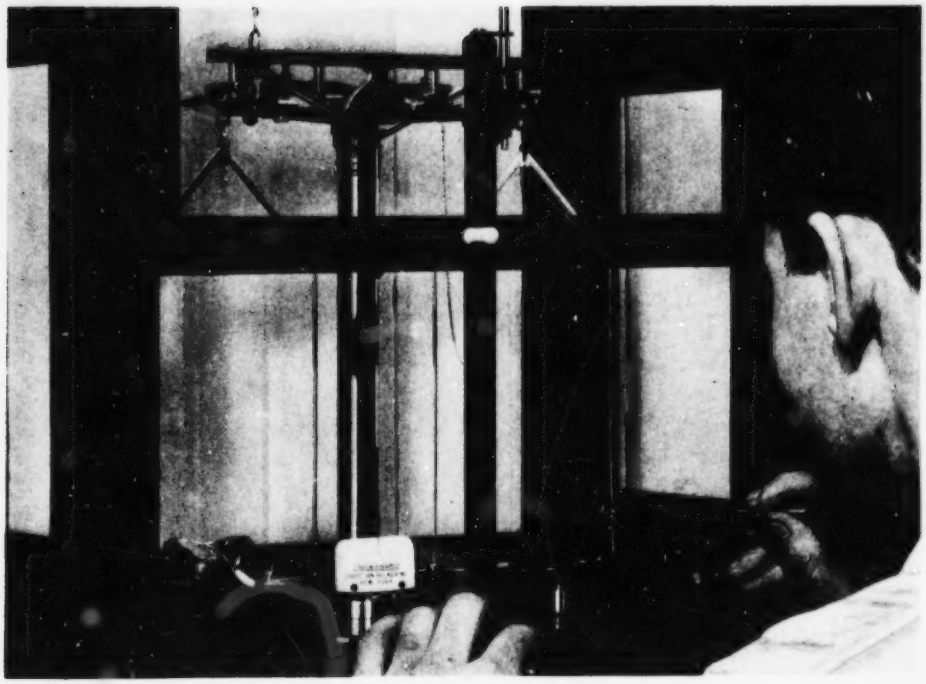
← An iron spectrum on the master plate, used for alignment purposes.

PLATE 9.

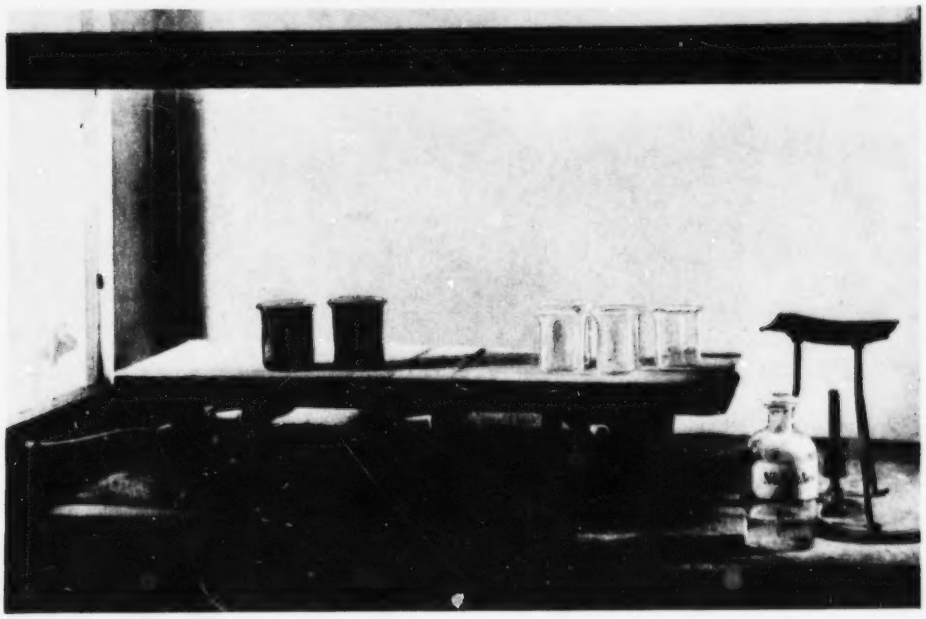


A comparator used for reading spectrograms, and a densitometer used for measuring the blackness of the lines.

PLATE 10.

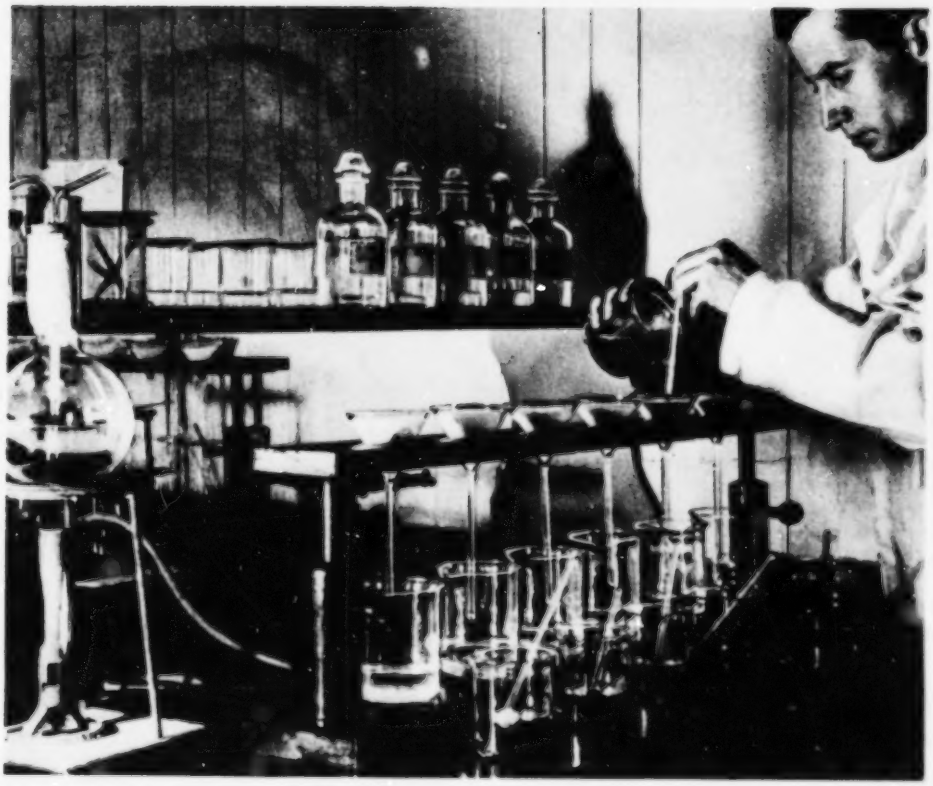


A.—Weighing a sample of powdered ore for analysis in the wet laboratory. This particular sample is to be assayed for zinc.



B.—Dissolving the zinc ore sample in acids.

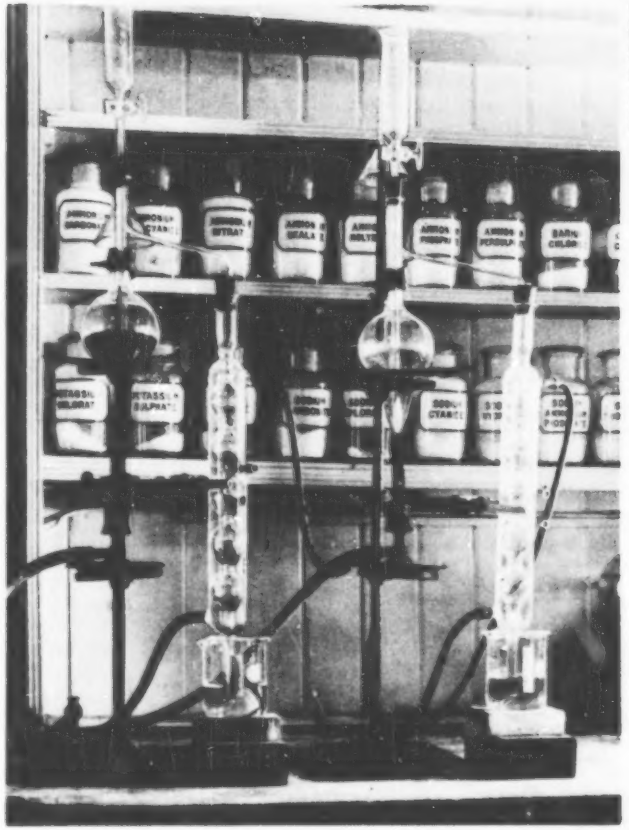
PLATE 11.



Interfering metals have been precipitated as solids, but the zinc has remained in solution. The picture shows these solids being separated mechanically from the zinc solution by filtration through special paper cones.

PLATE 12.

A.—Titration of the zinc solution.

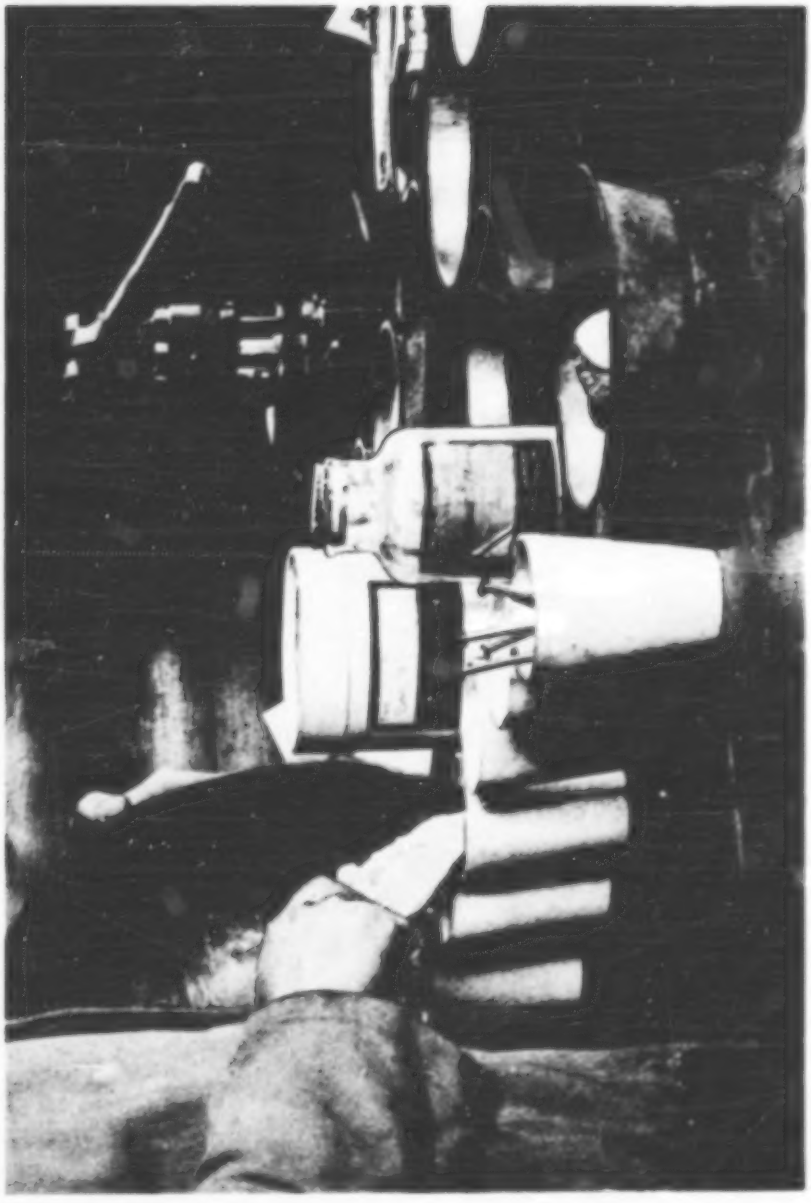


B.—Distillation apparatus used in determination of arsenic in ores.

PLATE 13.

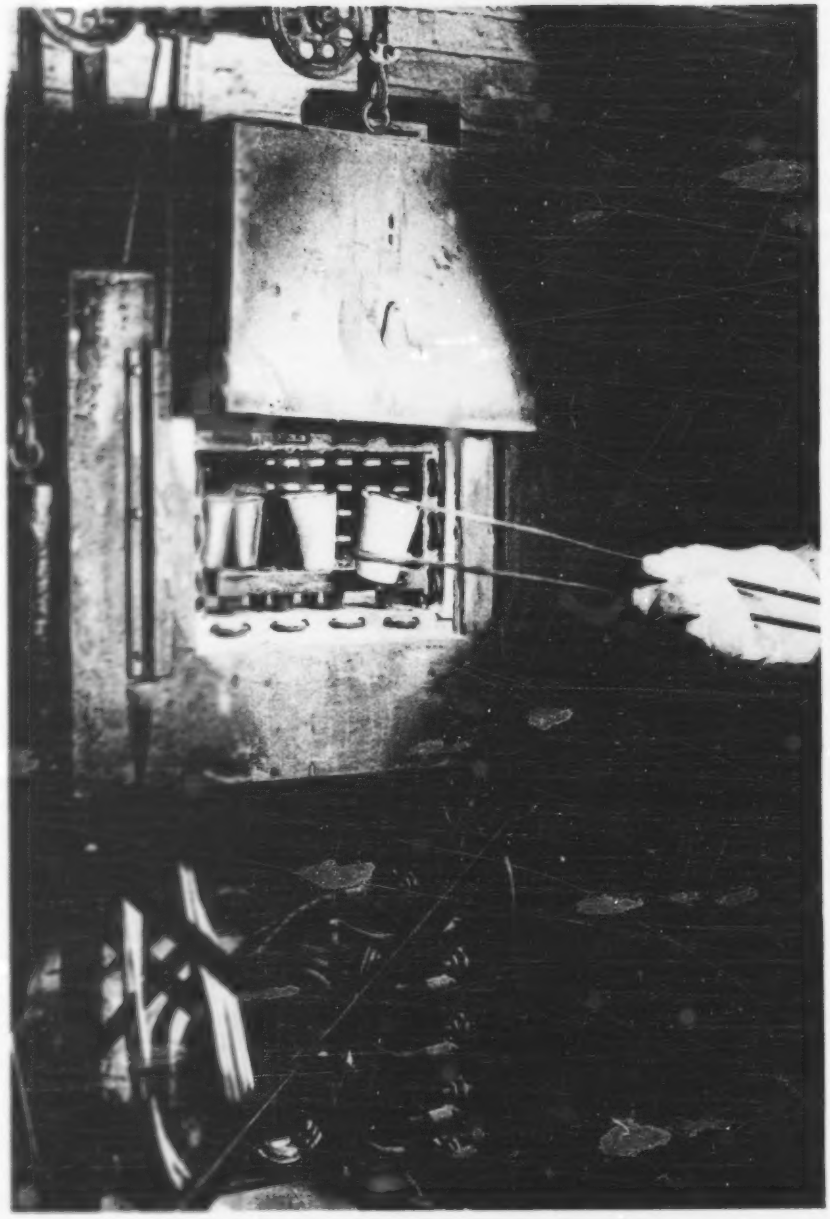
A complex operation in special analytical work.

PLATE 14.



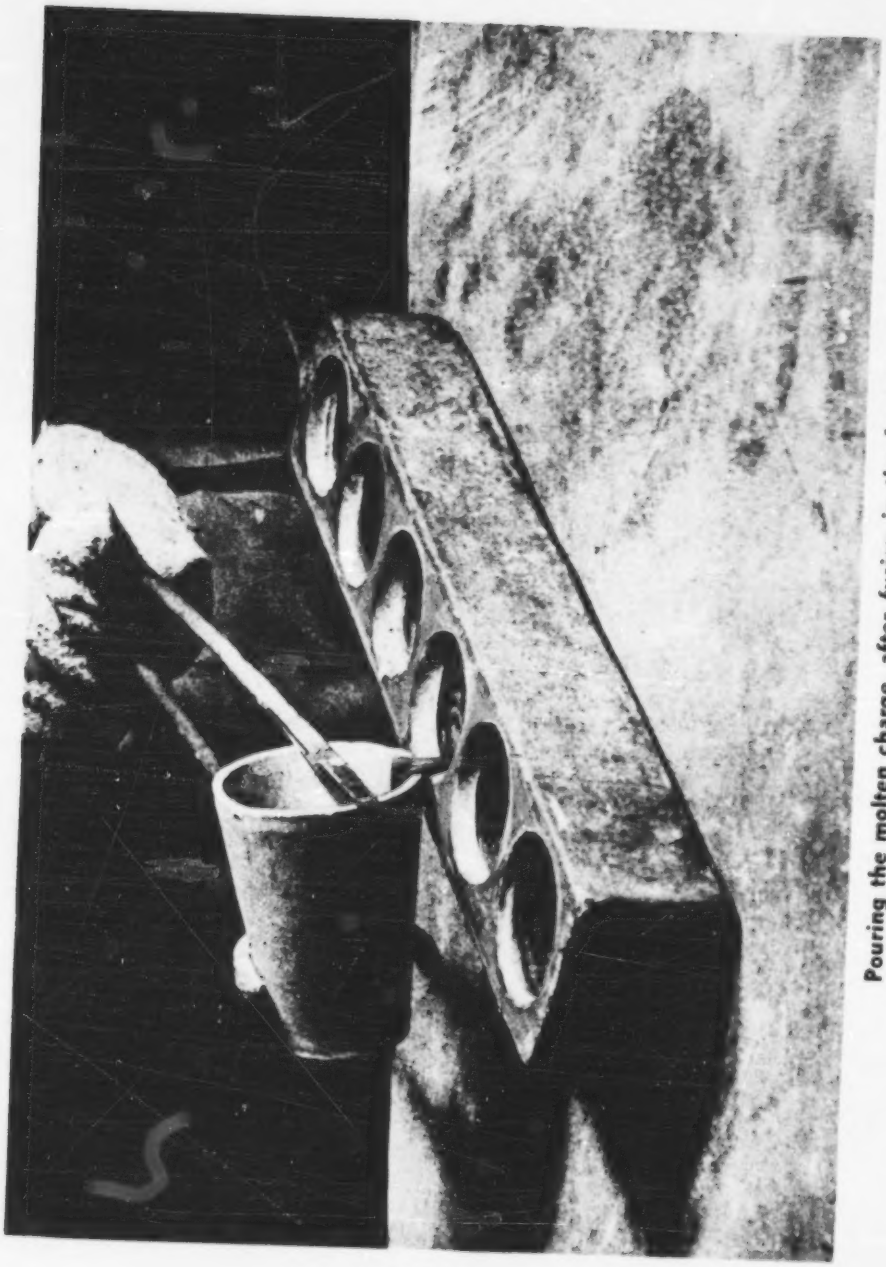
A mixture of ore and fluxes being put in a crucible for a precious metals assay.

PLATE 15.



Placing the fireclay crucibles, containing ore and fluxes, in the electric furnace for fusion of the charge.

PLATE 16.



Pouring the molten charge, after fusion in the furnace.

PLATE 17.

A.—Cooled slag with lead button attached.

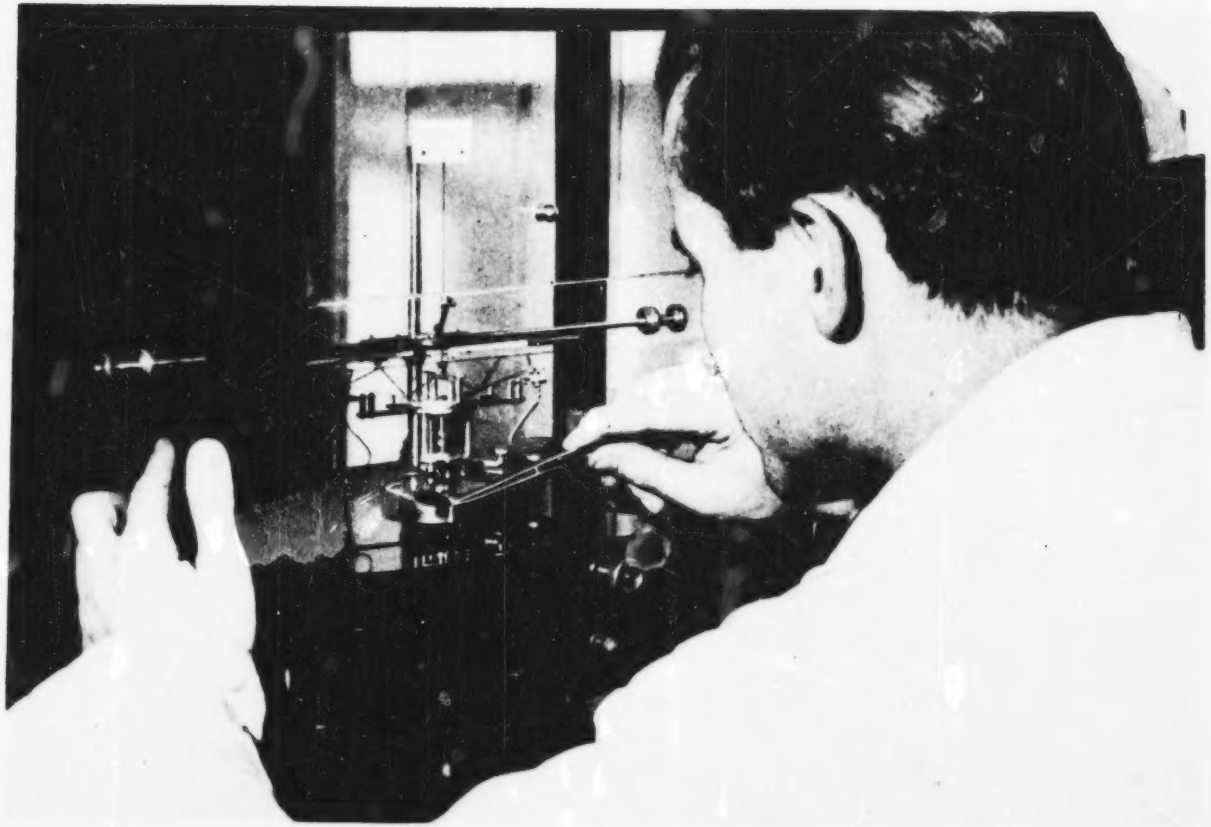
B.—The lead button containing all the precious metals, after the slag has been hammered from it and discarded.

PLATE 18.

A.—Cupellation in progress in a furnace at about 1,200 degrees Fahrenheit. The bright surface visible in each of the cupels is molten lead. It is oxidizing to lead oxide, part of which is volatilizing and part being absorbed by the cupel itself.

B.—A cupel with an exceptionally large silver bead remaining at the completion of the cupellation process.

PLATE 19.



Weighing the gold bead on a sensitive balance.